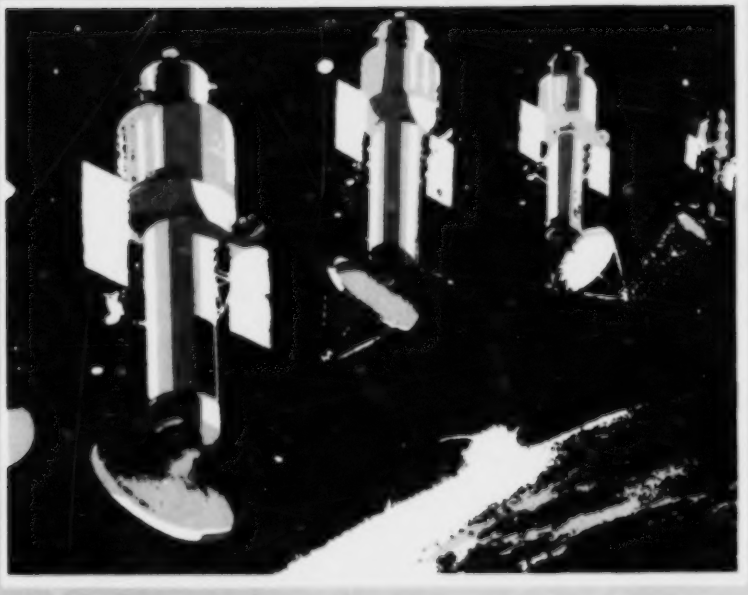
S1
.114/3
:St 8

CENTER FOR
THE STUDY OF
FOREIGN AFFAIRS

COLUMBIA UNIVERSITY
THE
LIBRARIES
DOCUMENTS
SERVICE CENTER

STRATEGIC DEFENSE IN THE 21st CENTURY

Edited by Hans Binnendijk



FOREIGN SERVICE INSTITUTE
U.S. DEPARTMENT OF STATE

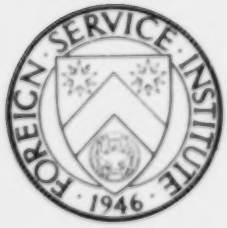
For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, DC 20402

CENTER FOR
THE STUDY OF
FOREIGN AFFAIRS

STRATEGIC DEFENSE IN THE 21st CENTURY

Edited by Hans Binnendijk

1986



FOREIGN SERVICE INSTITUTE
U.S. DEPARTMENT OF STATE

The views expressed in this publication are solely those of the speakers and do not necessarily represent the views of the Center for the Study of Foreign Affairs or the Department of State.

Library of Congress Number: 86-600547

Department of State Publication
Foreign Service Institute
Center for the Study of Foreign Affairs
Released August 1986

Table of Contents

Preface: Hans Binnendijk vii

Session I: Overview—The New Strategic Defense Debate 1
James A. Abrahamson 1
Alex Gliksman 9
Discussion 16

Session II: The U.S. Research Program 21
Gerold Yonas 21
Edward T. Gerry 31
Peter Sharfman 34
Discussion 41

Session III: The Soviet Research Program 45
Lawrence K. Gershwin 45
Sayre Stevens 49
Discussion 52

Session IV: Arms Control Implications 61
Gerard C. Smith 61
Dan Quayle 64
James H. Holmes 68
Discussion 69

Session V: The SDI and Strategic Doctrine 75
Leon Sloss 75
Walter Slocombe 80
Discussion 84

Session VI: Strategic Defense and the European Allies 93
Robert Hunter 93
Maurice Eisenstein 97
Discussion 102

Biographic Material 109

Text of President Reagan's March 23, 1983, Speech 117

Text of the ABM Treaty 119

Glossary of Terms 129

Bibliography 143

Acknowledgement for Charts and Photographs

The photos and charts used in this book are courtesy of the Defense Department, the Strategic Defense Initiative Organization and U.S. National Laboratories working under contract to the U.S. government. The one exception is taken from Harold Brown's "Is SDI Technically Feasible?" in *Foreign Affairs*, Volume 64, No. 3, 1985, page 443, (copyright, 1985, Council on Foreign Relations, Inc.) used with permission.

Preface

On March 23, 1983, President Ronald Reagan called upon the scientific community in the United States to turn its great talents toward developing a strategic defensive capability that would "give us the means of rendering these nuclear weapons impotent and obsolete." The vision of a strategic defense in the twenty-first century raises a host of highly controversial issues related to technology, Soviet intentions, arms control, strategic doctrine, and relations with our allies. To many it offers hope for a world in which the American and Soviet people are no longer held hostage to nuclear destruction. To others it threatens to destabilize a world kept safe from nuclear war for over forty years. The Strategic Defense Initiative Organization (SDIO) is coordinating research to determine whether the effort is technically feasible, and the outcome is already hotly contested. Few contest, however, that the Soviets are conducting their own fairly well developed strategic defense program. The impact of SDI on arms control is also a matter of lively debate both in the United States and in Europe.

To examine these and related problems, the Foreign Service Institute's Center for the Study of Foreign Affairs hosted a day-long conference on October 16, 1985, which featured fourteen speakers expert in various aspects of the SDI effort. Speakers of differing views were chosen on a nonpartisan basis so that all sides of the question could be considered in an academic environment. The proceedings were transcribed, reorganized, edited, and updated, to be published in this volume. The various participants present their own personal assessments and do not necessarily represent the views of the State Department or of the Administration.

The Center has designed this volume to serve as a primer on strategic defense issues. To accomplish this, we have added material in the appendix to supplement the diverse views presented in the text. The appendix includes a glossary of terms used in the SDI debate; an annotated bibliography; the text of the ABM Treaty and its Agreed Statements, Common Understandings, and Unilateral Statements; and the relevant portion of President Reagan's March 23, 1983, speech. There is also a section of photos, sketches, and charts to ilustrate various aspects of the issue.

The first session presents two different views of the overall debate. Lt. Gen. James Abrahamson, Director of the Strategic Defense Initiative Organization, argues that the SDI responds to several adverse trends long recognized by the Joint Chiefs of Staff, including the failure of existing agreements to halt the arms race, Soviet efforts to develop a strategic defense, and the threat that technology may lead to

an anti-submarine warfare breakthrough and hence destabilize the current deterrence regime. Abrahamson states that SDI's objective is not just to defend U.S. missile silos, but to create a much more effective defense. The goal, he says, is to create a layered defense, with a highest priority on destroying Soviet missiles in their boost phase. He reports that the greatest progress has been made with free-electron ground-based lasers and that the SDIO can begin to cut off a decade worth of research in this area by skipping steps in the research.

Alex Gliksman, Director of Strategic Defense Studies at the United Nations' Association of the U.S.A., gives a historic overview of the debate and reviews the arguments employed by both the proponents and the critics. He points out that the Administration-appointed Fletcher Panel concluded that offensive constraints are important if strategic defenses are to protect the U.S. population. He argues that SDI proponents disagree on both their assessment of technical capabilities and on the goals of SDI. The proponents, he says, tend to stress the technical advances made in non-nuclear defenses since the 1972 Anti-Ballistic Missile Treaty was signed, while opponents stress the vulnerabilities of this technology to Soviet countermeasures.

The second session focuses on the status of the U.S. research program. Gerold Yonas, Chief Scientist of the SDIO, provides a detailed assessment of U.S. capabilities and the basic direction of the program. He states that nearly half of the SDI budget is dedicated to data collection and processing, and that Soviet countermeasures in this area may be defeated by employing "interactive" rather than "passive" observations. He believes that the successful June 1984 Homing Overlay Experiment demonstrates the U.S. capabilities with regard to missile interception and destruction. Speed-of-light systems, such as the chemical laser, will be required for intercepts during the short boost phase. Kinetic energy intercepts are most likely during the longer mid-course phase of the missile's trajectory. The SDIO is investigating precision homing and high explosive fused warheads to improve kill probabilities during the terminal phase. Yonas concludes that cost will be the dominant issue with regard to most of this technology. He appears fairly confident that the United States can develop a system which meets the accepted criteria of being survivable and cost effective at the margin.

Edward T. Gerry, President of W.J. Shafer Associates, agrees with Yonas that new technologies in computers, sensors, and lasers have created a cost exchange which may be favorable to the defense. He further argues that by dispersing SDI interceptors to smaller platforms, they can be made more survivable.

Peter Sharfman, International Security and Commerce Program Manager at the Office of Technology Assessment, challenges the views of Yonas and Gerry. He argues that survivability of the SDI

system's functions depends upon the system architecture, and not enough work has been done in this area. He further argues that even with a highly effective strategic defense, the Soviets will still be able to target our cities, and that unless the Soviets agree to major reductions in offensive forces, assured survival of the U.S. civilian population will not be possible. He projects a possible eight-fold increase in spending on the SDI between 1984 and 1990 and discusses alternative funding options.

The third session analyzes the Soviet strategic defense research effort. Lawrence K. Gershwin, National Intelligence Officer for Strategic Programs at the Central Intelligence Agency, states that Soviet strategic defenses are intended to provide the degree of protection for the leadership and for military facilities necessary to end a nuclear war on their terms. The Soviets, he says, have the major components for an ABM system that could be used for widespread deployments, including radars, above-ground launchers, and high acceleration missiles. He does not judge, however, that it is likely that the Soviets would in fact move out to such a deployment in the near term. The Soviets are also expected to test the feasibility of a ground based laser system for terminal defense in the near future, but an operational laser defense system could not be in place until after the year 2000. Mr. Gershwin's symposium comments were off the record but similar to his recent testimony before the Senate, which is presented here.

Sayre Stevens, President of the National Security Research Group of the Systems Planning Corporation, believes that the Soviets may be in far better shape than the United States to develop strategic defenses because of national character and procurement patterns. He argues that because of the U.S. national character, we must build a long-term consensus that the SDI is cost effective and will do 100 percent of the job, a difficult thing for a "sprinter" to do. The Soviets, he says, are "long distance runners" who have a "relentless approach" and see value in doing 5 percent of the job. Since building strategic defenses is a long-term effort, these differences are cause for concern.

The fourth session analyzes the arms control implications of the SDI. Gerard Smith, Chairman of the Arms Control Association, states that the United States must choose between arms control and strategic defense. He says that the prospects for U.S. compliance with the ABM Treaty by 1988-1989 are not good. The new U.S. interpretation of the treaty, Smith says, probably would permit the United States to build exotic defensive systems as long as we do not deploy them. He believes that this interpretation is an incorrect reading of the treaty's negotiating history and that the United States should return to the more restrictive one which limits SDI activities to research. He does not believe the Soviet Union will cooperate with

the United States in providing for a stable transition to strategic defense.

Senator Dan Quayle of Indiana takes exception to Ambassador Smith's views, arguing that the SDI is a stabilizing factor in the strategic balance and that it will be very helpful to arms control in the long run. Senator Quayle says that the basic assumptions of the ABM Treaty have proven to be false and that the United States should use its strength in defensive technology to find alternatives to the existing "hair trigger" strategic balance. He says the Administration may lose some of its support for the SDI in Congress if its interpretation of the ABM Treaty is so restrictive that the SDI is limited to the laboratories.

James Holmes, Director of the State Department's Office of Strategic Nuclear Policy, states that the U.S. SDI research program will continue to be conducted in full accord with a restrictive interpretation of the ABM Treaty. He argues, however, that it is clear that the Soviets do not feel bound by a restrictive treaty interpretation. He says a U.S. decision point will be reached early in the 1990s on whether to proceed to development and deployment of an SDI-related system. He defends the Administration's broader interpretation of its authority under the treaty and its agreed statements, which would eventually allow the United States to develop and test an SDI-related system.

The fifth session considers the impact of the SDI on strategic doctrine. Leon Sloss, President of Leon Sloss Associates, argues that the SDI is consistent with the goals of the "countervailing" strategy developed by the Carter Administration and is a response to the nuclear freeze movement. He reviews three decades of strategic doctrine to show that the SDI is the next logical evolutionary step in the process. He says that strategic defense is already here, and that it should be used to strengthen deterrence rather than as a substitute for offensive forces.

Walter Slocombe, an attorney with Caplin and Drysdale, agrees that strategic defense is here to stay, but he feels it will pose a significant challenge to U.S. and NATO strategic doctrine. He believes that a complex strategic defense system will create increased pressures for a preemptive attack in time of grave crisis because that system itself is vulnerable. He further believes that the SDI will have a negative effect on the NATO doctrine of flexible response because a limited Soviet strategic defense could reduce the effectiveness of European nuclear forces and would complicate the notion of controlled escalation. He says that mutual assured destruction will remain a fact of life and, due to the economic and political costs of the SDI, funds should be diverted from it to other programs that enhance deterrence.

The final session analyzes the impact of the SDI on our European allies. Robert Hunter, Director of European Studies at Georgetown University's Center for Strategic and International Studies, states that the European allies are almost unanimously opposed to the U.S. approach to the SDI. They might accept certain aspects of strategic defense related to enhancing deterrence, but they fear that the ambitious U.S. goals might undermine arms control, lead to a "decoupling" of U.S. and European security, and divert scarce funds from conventional defense programs. He concludes that the British and West Germans are cooperating "up to a point" so that they will not be frozen out of technological advances.

Maurice Eisenstein, SDI project leader for the RAND Corporation, counters that general support within Europe for the SDI is growing because it is now being seen as a research and development project to be conducted within ABM Treaty limits. He observes that while most of the European defense elite opposes the SDI, the general population thus far seems to be supportive. This gives European governments more maneuvering room than they had on the cruise missile issue, but it also provides a tempting target for Soviet propaganda. The long-term implications of the SDI for NATO depend on the answers to a series of questions which he poses but believes cannot yet be answered.

Between October 16, 1985, when the symposium was held, and publication of this volume, several important developments occurred relating to the SDI. They include:

- a successful summit meeting between President Reagan and General Secretary Gorbachev;
- technical successes in SDI research, including improvements in free electron laser technology and a successful test of the flexible lightweight agile guided experiment (called FLAGE and previously called SRHIT SEEKER) against a moving target;
- the tragic loss of the space shuttle Challenger and the failure of other U.S. and European space delivery systems;
- an Administration statement that the United States will no longer be bound by the SALT II Treaty;
- Soviet presentation of a new arms control proposal that links a U.S. agreement to continue the ABM Treaty (with clarifications) for 15 to 20 years with Soviet concessions on offensive nuclear systems;
- a statement by President Reagan that the Soviet Union has begun to make a serious effort on arms control;
- new agreements negotiated between the United States and Britain, West Germany, and Israel with regard to cooperation on SDI research;

- continued efforts in Congress to cut SDI funding by a third, limit it to the bounds of the ABM Treaty, and redirect the goals of the program to focus on defense of U.S. strategic forces;
- reiteration by Defense Secretary Casper Weinberger on July 1, 1986 that the SDI should retain a long-term goal of population defense;
- a letter sent from President Reagan to General Secretary Gorbachev in late July of 1986, which reportedly states the United States' willingness to discuss continued adherence to the ABM Treaty for seven and a half years and to negotiate deep reductions in offensive systems; and;
- the clear prospect of a summit meeting late in 1986.

I would like to thank Diane Bendahmane for her outstanding editorial assistance throughout this project. I would also like to thank Alex Gliksman for his help in suggesting speakers and selecting illustrations. Finally, I would like to acknowledge the assistance of Nancy Arneson for her help in assembling material for the appendix. Without their help, this volume could not have been produced. We hope that our effort will enhance the understanding of this complex subject.

Hans Binnendijk
July 1986

Session I

Overview: The New Strategic Defense Debate

FIRST SPEAKER: JAMES A. ABRAHAMSON
(Director of the Strategic Defense Initiative Organization)

I'm very pleased that the Foreign Service Institute has initiated this discussion on the Strategic Defense Initiative. The issue is how we can ensure that the United States, our allies, and our way of life can truly survive. How can we seek to achieve real stability, perhaps even in the face of very difficult crises in the future?

The search for real stability.

This new program does not imply that everything the United States has done in the past has been wrong, nor does it repudiate how we have gotten to where we are. The SDI grew out of a recognition of the state of technology and the long-term trends in the future, and that was what was behind President Reagan's March 1983 speech.*

That speech caught many by surprise, especially those who considered that the strategy of mutual assured destruction, particularly in its simplest form, the form of simple retaliation, was effective for all time. But there were others who had been thinking for a long time that strategic and technological trends may not assure real survival in the next century and beyond.

Current technology inadequate for future.

Before his speech, the President had several sets of advisors. The SDI did not just come full-blown in that speech. While he did not have a careful, in-depth study by the entire administration to support his speech and to examine this change in policy, he was receiving independent advice from many technologists. The Joint Chiefs of Staff were telling him that the pendulum had swung too far in the area of offensive retaliation and that the United States should definitely begin to reconsider the

*The text of this speech may be found in the appendix of this book.

strategy of defense across the entire spectrum of our security policy, not merely in the area of ballistic missiles. They urged him and have continued to urge him to reaffirm their very basic belief that the concepts and the technology that we have relied on so far are not now adequate and will not be adequate for the future.

A number of trends worry the Joint Chiefs of Staff. I'd like to mention those very briefly, and then I'd like to spin a tale about what strategic defense might look like after the year 2000.

Soviet offensive build-up.

The first trend to consider is the offensive Soviet build-up in the context of the 1972 ABM (Anti-Ballistic Missile) Treaty.* When we signed that treaty we embarked on an incredible experiment, and we embarked on it in good faith and with high hopes and expectations. At that time we as a nation agreed and the Soviets agreed, at least in form--the question is how much in substance--to leave our populations utterly defenseless to the worst and most dangerous threat that we could define at that point. Certainly a factor was that we didn't know how to defend against that threat. The experiment was that we would agree that we would remain defenseless in the hope that, by doing so, we would not threaten the other side's ability to threaten us. The hope was that we would create an atmosphere in which arms control and arms limits of all kinds could operate and people would therefore not want to build any more than just a minimum number of offensive nuclear weapons.

There were suggestions in 1972 that the ABM Treaty itself should be reconsidered if the signatories were not able to achieve certain offensive limitation agreements in a fairly short period of time—within five years. Because of that, there is an escape clause in this treaty that isn't found in many treaties. The escape clause says that the signatory nations will review the treaty every five years, so that they could withdraw from it with six months' notice if new developments that applied to their security made it prudent to do so.

*The text of this treaty may be found in the appendix of this book.

This rather grand experiment has not worked. The Soviet Union and we ourselves have been in an action and reaction cycle. We have continued to build up two nuclear arsenals so that the Soviets have enough nuclear weapons to destroy all of the targets (including both civilian and military targets) in this country several times over, and we have enough to destroy not all, but many of the Soviet Union's targets, although we have a different targeting problem than the Soviet Union.

So the first trend that concerned the President and the Joint Chiefs of Staff was the continued long-term build-up of offensive weapons that was not slowed by either the ABM Treaty or by subsequent arms limitation agreements. The total megatonnage has gone up on the Soviet side. Ours has gone down in terms of deliverable megatonnage.

Soviet defensive efforts.

The second trend is the Soviet effort toward defenses. The Soviets have maintained the world's only operational ABM system. At this point the system does not have enough weapons to defend a larger area than just a portion of the Moscow complex and the key targets that are right around that city. Nonetheless the Soviets have not just simply upgraded that system and operated it; they are building an entirely new system with huge new components. The Pushkino radar is the central command and control complex. Sketches of that particular radar show its colossal size. Two full football fields could be put on top of it. One has to wonder what its real capability is for battle management and why it was built so big. The Krasnoyarsk radar is also a serious problem. It is within treaty limits to build peripheral radars around the Soviet Union, but the Krasnoyarsk radar is not on the Soviet periphery. It's placed 4,000 kilometers in from the periphery. One has to wonder when construction on it was started. It certainly was not started after the President's 1983 speech. Planning for it probably started some time in the mid-1970s, probably shortly after the ABM Treaty was signed. The Soviets had to conduct site surveys and had to deliberately select a site inconsistent with the treaty. One has to ask why they would do that. Why would they challenge the treaty in that particular way? In

The Krasnoyarsk radar.

my judgment it's because the location is very critical. It "closes the circle" in terms of providing a nationwide capability of radars for ballistic-missile defense. With this radar the Soviet Union could maintain accuracy in the handoff to ABM interceptor components of the more traditional kind to cover the mid-section of the country.

Thus we see that the Soviets have been working on an ABM command and control capability. We can't confirm that, of course, until those radars begin to operate. But nonetheless, battle management radars were recognized in the technology of the early 1970s to be the critical element in a full ABM capability. The kinds of ABM interceptors that the Soviets have at present could easily be manufactured in mass production and could be deployed around a substantial area of the Soviet Union fairly quickly.

Could that kind of a system ever be a really effective ABM system? In my judgment, the answer is clearly no. I think that the United States could overtarget it and overcome it if we embarked on a first strike. But the Soviet ABM system could be used, if the Soviets chose to do so, very effectively against a ragged retaliatory strike. So the real threat of what the Soviets have at present is its potential for undercutting the U.S. offensive retaliatory bases for stability in today's strategy (provided the United States did not have a similar defense).

Soviet ground-based lasers.

But the Soviets didn't stop there. They have been working for a very long time in many of exactly the same technologies that we are in the SDI. They have large ground-based lasers in place that they have been experimenting with for a very significant period, and there are many indications that they have as active a program as we do in advanced technologies.

The third trend that concerned the President and the Joint Chiefs is technology itself. Right now we rely very heavily on our submarine-launched ballistic missiles. But there is no guarantee that future technology will not make this element of our strategic deterrent obsolete.

The search for a more stabilizing strategy.

Those kinds of concerns make one ask if there is a more stabilizing kind of strategy, and the answer to that depends very heavily on what the United States can achieve technically. Can we find a way to build a very effective defense? Of course, that's what the SDI is about. It is a program that has been approved only through the research phase. People ask where research stops. It stops with the treaty, and the President has made quite clear that the United States will limit the SDI far short of the full latitude allowed by the treaty.

Under the treaty, we are allowed to proceed with research, just as the Soviets have, and that's what we are doing. We are looking at the kind of advanced systems that could offer an effective defense in the future. (Nothing is perfect and there is no such thing as a perfect defense.)

There is a substantial difference between the SDI and trying to defend silos. Our objective is not just to defend silos. Such an objective would continue to support the mutual assured destruction or assured retaliation doctrine. A terminal defense around those silos is only an extension of a wall around the silo that goes up into space. That is not what we are trying to do. We are trying to see if there are capabilities that could allow us much more effective defenses, the kind that, while they may not be perfect, would provide stability in a crisis. These defenses would provide a deterrent capability because they would cause the Soviet targeteer to conclude that he could not assure his political leadership that a first strike would be successful from a military viewpoint. The risk associated with the lack of confidence in a first strike is part of the deterrence concept. The most important thing is that the Soviets must never be tempted to think that they can achieve any meaningful military objective with a first strike.

Layered defenses.

Our job is to build a defensive system that will create that level of lack of certainty on the part of the Soviet targeteer. The best way to do that is to build a layered defense. The United States is researching systems which might destroy a very large percentage of a strike coming from the Soviet

Boost phase.

Union or from anywhere else in the world in the boost phase, the time from launch to burnout.* That's our highest priority because destroying a missile in the boost phase means not just destroying that missile but also destroying all of its MIRVed (multiple independently-targetable reentry vehicle) warheads and its capability to put out perhaps as many as hundreds of decoys which would make the job later on very difficult.

Post-boost phase.

It is not sufficient, however, to have only a boost phase layer of defense, even if it is effective. The United States must also have layers behind that that are equally effective and difficult for the Soviet targeteer to know that he can penetrate. Therefore, the next layer is the post-boost phase. For an SS-18 missile, the current mainstay of the Soviet offensive force, post-boost phase is about five minutes. If the Soviets really wanted to invest in an entirely new missile force, they might be able to build something that we call a fast-burn booster, which is a ballistic missile that can burn out much more quickly than current versions, possibly before exiting the atmosphere. This doesn't mean that we couldn't find a way to destroy fast-burn boosters in the upper reaches of the atmosphere. But a fast-burn booster is not sufficient unless it is combined with an entirely new way of deploying warheads quickly as well. (It is easy for critics to create technology like a fast-burn booster in their minds. However, it is not so easy to actually develop such a thing, and the Soviets may not be willing to make the immense investment associated with developing such weapons.)

---

* There are several phases of a missile trajectory. The first is the "boost phase," from launch to burnout of the final stage. The "post-boost phase" begins after the booster's stages have finished firing and covers the time during which the various reentry vehicles (warheads) are dispensed by the post-boost vehicle, or "bus" as it is sometimes called, and are independently placed on ballistic trajectories towards their targets. The "midcourse phase" is the long period of a warhead's flight to its target after it has been dispensed from the post-boost vehicle until it reenters the atmosphere over its target. During the "terminal phase," the warheads and penetration aids reenter the atmosphere. A layered defensive consists of systems built to destroy the missile at each phase.

The United States is thinking not only about the systems today, but also about how they will develop in the future. As I mentioned, we are considering several layers, starting with the boost phase, then the post-boost, then a space-based layer midcourse, and finally, to destroy warheads that would penetrate each of those layers, some terminal defenses located primarily around our high-value target areas. Again, the job is to tell the Soviet targeteer that he cannot get through to accomplish a meaningful military objective.

Space-based mid-course layer.

What kinds of systems is the United States working on? We have made a great deal of progress in the area of ground based lasers. We have progressed enough in our efforts on these kinds of advanced weapons so that we are now willing to start skipping steps and possibly cut off nearly a decade from the time that was previously planned for research and development of large ground-based lasers. These lasers may become capable enough so we can fire them up through the atmosphere, bounce the beam off of a mirror, and then have that beam destroy missiles in the boost phase.

Laser technology promising.

The Soviets are working on chemical lasers, carbon dioxide chemical lasers, and other older laser technologies. The laser technology that we have made the most progress in is what we call the free-electron laser, a laser in which electronics are converted to coherent light. As recently as three years ago, this was just an idea in several people's heads, and there were some very small laboratory versions. Today, we have one large free-electron laser operating out at Livermore Laboratories where we have achieved tremendous efficiencies. We have demonstrated new concepts which should enable us to step up to a very advanced and a highly accelerated development program. We will thus soon see if we are in a position to use this system to destroy missiles across great distances.

Ground-based lasers, however, are not sufficient. We need lasers that can penetrate the atmosphere. While we don't have all the answers, we recently demonstrated that we can project laser energy up through the atmosphere and correct for the distor-

tion caused by the atmosphere. This is the result of a great deal of work that has been done over a long period of time. During the spring of 1985 we demonstrated that we could direct a high quality laser beam against airplanes at small distances. In June of 1985 we did a risk-reduction experiment against the space shuttle just to make sure our equipment worked properly. In the fall of 1985 we fired two small instrumented sounding rockets up above the atmosphere, and in fact demonstrated that at very low powers we can indeed correct for the atmosphere. The next challenge is to see if we can use these same techniques for a very high-powered laser.

Directed energy weapons.

The next job is to see if directed energy weapons can be pointed and tracked accurately. We are about a third of the way there, but we are at the limit of what can be done from the surface of the earth. Other directed energy devices, such as particle beams, could be very effective defensive weapons and also an effective means of discriminating between decoys and warheads with nuclear material in them.* We have one of these systems operating today at the Los Alamos Laboratory. It's a small-scale model and it's certainly not cost-effective yet, but we do understand the physics and now our problem is to see if we can scale it larger and make it less expensive.

The thrust of the SDI in nearly every one of our research areas is to be able to offer to a future President, a future Congress, and a future leadership of the Western world options for defensive systems which will be cost effective and which will provide stability.

We hope to implement the SDI program in such a way that we can have a stable transition from the current offensive deterrent system to a defense-oriented system. That may be difficult. We are discussing such a transition with the Soviets and clearly they haven't bought it yet—not by any means. Currently, the Soviets are doing, I think,

*Directed energy is focused energy in the form of particles or laser beams that can be transmitted over relatively long distances at the speed of light. A particle beam is a stream of atoms of subatomic particles.

Soviet opposition to a defense-oriented system.

what is cheapest and easiest for them, and that is to help us talk ourselves out of proceeding with the technology. That's clearly the simplest way for them to maintain whatever their objectives are.

Nonetheless, I think we have to keep discussing and working with them to see if there is a way to ensure that they understand that mutual defenses will be in their interest as well as ours. That's a tall challenge. But there has been a great deal of progress in the technical side of the program. In fact, in my judgment, we can do the technical program if we are resolved as a nation to do it. Our history shows that when we decide that something is truly worthwhile and we maintain the national will to proceed, technical solutions can be found. Technical solutions are the easiest side of this problem. But it has to be carefully thought through politically, strategically, and in an arms control context as well.

SECOND SPEAKER: ALEX GLIKSMAN
(Director of Strategic Defense Studies, U.N. Association of the U.S.A.)

President Reagan's "Star Wars" speech.

In concluding a nationally televised address on March 23, 1983, President Ronald Reagan departed from the theme of his talk to present his "vision of the future." This vision spoke of defenses, built upon emerging technologies, with a capacity to "intercept and destroy strategic ballistic missiles before they reached our own soil or that of our allies." In consequence, nuclear weapons would be rendered "impotent and obsolete."

While few can recall the rest of the President's address, the brief reference to strategic defense has had a dramatic effect on strategic thinking. What is now frequently referred to as the "Star Wars speech" gave birth to the largest research program in American history, the Strategic Defense Initiative (SDI). It has also produced what is perhaps the most significant and heated debate on nuclear strategy and arms control in decades.

In the hope of capturing the essence of this national debate, I would like to review the key

---

Alex Gliksman spoke later in the program, but his comments have been placed in the overview section for presentational purposes.

arguments employed by proponents and by critics of strategic defenses in general and the SDI in particular.

A shift in strategic planning.

Strategic defense is not a new invention. Nor is the present debate on strategic defense the first. From the late 1960s to the early 1970s, Americans engaged in a heated debate on the virtue of pursuing strategic ballistic missile defenses.

Ultimately, Congress and then-President Richard Nixon decided against the strategic defense option. In consequence, the United States signed the 1972 Anti-Ballistic Missile (ABM) Treaty which strictly limits the development, testing, and deployment of fixed ground-based strategic defenses and bans all strategic ballistic missile defense systems that are air-based, sea-based, space-based, or mobile land-based. Since laboratory research is unverifiable, at least under the verification provisions of the accord, the treaty permits research as a "hedge"—an insurance policy—against unobservable strategic defense activities by the other side.

While research continued over the succeeding thirteen years, there was little enthusiasm for deploying defenses of any kind. Under the ABM Treaty, as amended in 1974 by the Vladivostok accord, the United States was permitted to deploy a limited defense at a single location. But eventually, work at the site in Grand Forks, North Dakota, was stopped. Plans for a lesser, anti-tactical ballistic missile (ATBM) defense deployment, not constrained by the ABM Treaty, were also abandoned. As a result, the Patriot ATBM became the Patriot air defense weapon. Within the defense analysis community, few viewed defenses as a serious subject for discussion and little analysis was done.

All this has changed in the wake of the March 1983 speech. This is not to say that the currents evident in the new strategic defense debate were not present before. Rather, the President's concept called for so total a shift in the strategic environment that the SDI has become a focal point for raising concerns that are seemingly unrelated to strategic defense. As a result, the debate on the SDI is not only about the virtues of defenses, it is also about the significance to be attached to and the

viability of emerging technology, existing nuclear strategy, and current arms control policy in providing security and dealing with the Soviet Union.

Recent developments in technology.

While some believe that the 1972 ABM decision was wrong in the first place, others conclude that developments since 1972 demand a reassessment. Changes in several areas are noted by those who believe that the SDI is justified. First, technology is changing and holds the promise of overcoming the limitations of more traditional ballistic missile defenses.

In the 1960s and 1970s, defense technology referred to systems that were tied to the ground. Since the earth is curved, opportunities to intercept incoming nuclear warheads were limited to the so-called terminal phase—the very last few minutes of missile flight. Moreover, missiles travel at tremendous speeds— on the order of 18,000 miles per hour—and our ability to quickly identify, closely track, and accurately target nuclear warheads was meager, at best.

Problems with current defensive systems.

To make up for deficiencies in precision, anti-missile defenses, as proposed then, required detonating a nuclear explosive directly over or near to American territory. This was a cause for serious concern, since the electromagnetic pulse associated with such explosions could disrupt communications and military electronics all across the United States. In consequence, experts questioned whether defenses of this type would, in fact, hurt the defender more than the attacker.

Moreover, at the time of the first strategic defense debate, then-emerging strategic offensive technology, particularly multiple independently-targetable reentry vehicles (MIRVs), which allowed each missile to carry a large number of nuclear warheads, assured that these defenses would be rapidly neutralized, at far lower costs than the defenses themselves.

Proponents say that emerging technology can remedy these problems. Among other things, they believe that advances in space technology will permit attacks against Soviet missiles and their deadly cargo through all phases of flight. Most important, emerging technology may enable defensive weapons to loiter over the Soviet Union's missile fields and

attack rocket boosters soon after they are launched from their silos. No longer will the United States have to wait for attacking Soviet warheads to fly closer and closer toward targets in the United States before responding.

As a result, relatively slow moving booster rockets would be vulnerable. When a single booster can carry ten or more warheads, boost-phase attack obtains considerable leverage for the defender.

With advances in our understanding and application of high energy physics, we may be able to use a single power source to attack many targets, one after the other, almost instantaneously, and at very great distances from the defensive weapons themselves. Advances in sensor and in tracking and pointing technologies will permit us to detect, follow, and strike at objects in space and in the atmosphere, with high accuracy. Therefore, we may not need the brute force of a nuclear weapon to do the job.

Developments in communications and computer technology will greatly enhance our ability to rapidly command and expertly orchestrate an attack against tens or perhaps hundreds of thousands of warheads, decoys, and other penetration aids, designed to confuse the defender.

According to their proponents, advanced technology defenses, once deployed in layers, extending throughout a ballistic missile's trajectory, will end the threat-free ride that nuclear weapons enjoyed during the first 80 to 90 percent of flight.

Arms control considerations.

Technology was only one of the factors that made for the last decade's ABM decision. Arms control considerations were equally critical. Analysts concluded that, given the existing trends in offensive and defensive technology, the failure to constrain anti-ballistic missile systems would lead to two arms races: the first, between the defenses themselves and, the second, between the offensive forces designed to counter them.

The ABM Treaty was viewed in the United States as part of a broad U.S.-Soviet arms control bargain, which included not only the ABM Treaty's defensive constraints but also the Strategic Arms Limitation Talks (SALT) I accord's limitations on offensive weapons. It was the U.S. position that this broad

bargain involved the understanding that SALT I's offensive constraints were a first step toward deep nuclear reductions.

ABM Treaty compliance.

SDI proponents claim that the broad bargain of 1972 has not been fulfilled. They note, for instance, that two years after the ABM Treaty was signed, the Soviets deployed their deadliest missile, the SS-18, and later the SS-19. They claim that Soviet arms expansion continues to this day with the deployment of two new mobile missiles, the SS-24 and SS-25. In addition, they believe that even the narrow ABM Treaty bargain of 1972 has not met U.S. expectations. They note that the Soviets have never abandoned defense. The Soviets have maintained a defense around Moscow and are now upgrading that capability. Moreover, they point to evidence suggesting that the Soviets may be preparing to break free of the treaty's confines.

Item one in this case is the construction of a large radar at Krasnoyarsk, in Soviet Central Asia. The radar has all the markings of an ABM Treaty violation in the making. For some, the conclusion is clear: if the Soviets are not complying with the accord, why should the United States?

SDI proponents.

The failure to make a serious dent in the problem of nuclear arms reduction through political means has led SDI proponents to view technology as a complement to, and in some cases a substitute for, arms control.

Not all SDI supporters are of the same mind. In addition to differing on whether technology can serve as a substitute for negotiations, the SDI's backers are also divided on the nature of the SDI and its appropriate goals. Some are sure that the technology will work and that effective "people protection" will result. Included in this group are individuals who see danger in continuing to rely on the strategy of mutual assured destruction. For them, the moral imperative lies with seeking the means for "assured survival."

Others feel that judgments about the viability of exotic defenses are premature. For them, learning whether survivable and cost-effective defenses are feasible is what the SDI is all about. They support the SDI as a feasibility study, while reserving judgment on anything beyond research.

Still other supporters are doubtful that effective population defenses can be built. Nevertheless, they see virtue in partial, hard point defenses that would reduce the vulnerability of land-based missiles to attack by highly accurate Soviet intercontinental ballistic missiles (ICBMs). They believe that defenses can increase the uncertainties faced by Soviet planners. This would, they say, reduce incentives for launching a pre-emptive nuclear strike. Thus, they see in defenses a means for increasing security by enhancing deterrence.

SDI critics.

Critics of the SDI believe that the vision of making nuclear weapons "impotent and obsolete" is an illusion. While imperfect defenses may be feasible, no benefit is derived from having them. SDI detractors claim that proponents present an overly simplified view of the strategic environment and that security involves a great deal more than simply the development, testing, and deployment of strategic defenses.

SDI critics hold that the logic for strategic defense is built upon a critical fallacy: that an American deployment of strategic defenses will be the last move in the strategic chess game. This ignores the counter-actions that might be taken by the Soviet Union to defeat our efforts. For example, boost-phase attack is held up as a key virtue of future defensive technologies. But the boost phase is about 250-400 seconds long. SDI skeptics believe that the Soviets will do their best to make this period still shorter through the deployment of faster boosters. The technology for doing this is close at hand.

Vulnerability of SDI systems.

The vulnerability of SDI systems is another critical concern. Critics note that it is much easier to attack satellites than missiles. The current availability of anti-satellite (ASAT) weapons is evidence of this. Yet, boost-phase attack will be conducted by satellites. Therefore, critics believe that, in addition to developing the means to penetrate American defenses, the Soviets will acquire the weapons needed to destroy the defenses themselves.

In response, some say defensive weapons need not be deployed in space. All that is required are

"pop-up" systems. These would be launched into space at a moment's notice, ready to strike Soviet missiles. But two problems are noted here. Defensive weapons that are launched after Soviet missiles are in flight will have even less time to attack missiles during the critical boost phase. Moreover, the "pop-up" approach does not put an end to the vulnerability problem.

Even if the weapons themselves are based on the ground, the defense network will continue to require space-based elements to sound the alarm and coordinate the battle. And, these space-based elements will remain vulnerable to attack.

SDI detractors believe that strategic defense proponents grossly underestimate the awesome power of the weapons that the defense must counter. Nuclear weapons are a million times more powerful than chemical explosions of the same weight. If one weapon "leaked" through the defensive shield, surviving to destroy its target, a city could cease to exist. If 200 warheads survived, the United States would be devastated. If, for example, a defense were 95 percent effective and only 5 percent of the weapons arrived at their target, at current force levels, far more than 200 warheads would "leak" through.

The Fletcher team report.

In responding to those who look at the SDI as an alternative to arms control, the skeptics recall that immediately after making his March 1983 address, President Reagan commissioned former National Aeronautics and Space Administration chief James A. Fletcher to direct a study of strategic defense technology. The group, known as the Defense Technologies Study Team, not only prepared the research plan, which provided a basis for the SDI, but it also examined the strategic conditions required for the technology to work.

SDI skeptics regard the panel's latter finding as more important than the strategic defense program it proposed. The panel concluded that in the absence of constraints on Soviet offensive forces, chances were slim that a defensive system designed effectively to protect the U.S. population could be built. This judgment was confirmed by a September 1985 report by the U.S. Congressional Office of

The OTA report.

Technology Assessment (OTA). In the OTA's words, "Assured survival of the U.S. population appears impossible to achieve if the Soviets are determined to deny it to us." From this, skeptics conclude that even with the SDI there is no escape from negotiations.

But they also note that history and recent Soviet statements suggest that a Soviet Union faced by an American defensive buildup would probably try to overwhelm and break through the American defensive net. An offensive buildup is the most likely result. Given that it will likely remain cheaper to augment offenses than to add to the defense network, the Soviets will have few incentives to do otherwise. Some critics conclude that under present conditions a choice must be made. It is either strategic defense or arms control, there is little chance of achieving both.

Others believe that defenses may make sense in the future, after deep reductions are realized. If nuclear weapons were drastically cut first, then both sides might want defenses as a hedge against cheating.

But those who question the SDI generally agree that the considerations that went into the ABM decision of 1972 remain valid, at least at this time. They believe that, if the goal is to end the tyranny of nuclear weapons, then arms control, perhaps aided by technology, is the only approach that offers a chance for success.

These are some of the perspectives one finds in the new debate on strategic defense. It is impossible to render a final verdict on which viewpoint will ultimately decide the nation's policy. At the current time, the jury is still out.

Discussion

QUESTION:

Transfer of SDI technology.

Is there any serious attempt to see that the technology developed under the SDI will be transferred into the civilian sector, and what are the national security constraints on such transfers?

ABRAHAMSON:

A great deal of the research is very basic and cannot be protected. The laws of physics are the laws of physics and are also understood by the Russians. So surprisingly, a very substantial part of the program is unclassified, and that's good because it's important that our citizens, our allies, and the Russians understand where we are making progress. That's a factor in the stable transition to defense-reliance in the future.

There is a man in my program office whose job it is to consider which of the SDI technologies are going to be important to the U.S. civilian economy. Nonetheless, certain of the technologies are very sensitive; those are being carefully protected and will not be transferred.

QUESTION:

Could you discuss further the problems inherent in the sudden transition from one strategic doctrine to another?

ABRAHAMSON:

Transition from offense- to defense-oriented strategic doctrine.

Strategic defenses will not be implemented all of a sudden at 12:00 noon on June 30, 1999, or something like that. They will be built up slowly as we demonstrate that defense is cost effective. (To be "cost effective at the margin" any defensive system must create a powerful incentive not to respond with additional offensive arms, since those arms would cost more than the additional defensive capability to defeat them.) During this time we will discuss the problem with the Soviets and hopefully find a reasonable way to proceed. An area of major concern is the transition period. That has been the subject of a large number of war games as well as political-military strategy games. There has been a lot of writing and thinking about that, and there certainly isn't a unanimous conclusion that the transition will be stable. On the other hand, I don't believe that the people who have taken the position that it is unstable have proven their point either. It is responsible to proceed with this program through the research phase until we see that we have the

answers. Once we see that we have those answers, then it will make sense to proceed into development and later deployment.

QUESTION:

What do you see developing at the end of that transition period if offensive forces are reduced? How useful are partial defenses?

ABRAHAMSON:

End of the transition period.

The end of the transition gets to be rather exciting. Let me give you an example. Let's say the United States had a reasonably effective defense against 10,000 warheads, and used the defense as a means to convince the other side that offensive weapons are not all-powerful and should be cut in half. Then that defensive system would be twice as effective against the reduced offensive threat. And if there were only 2,000 warheads, the defense would become much more effective. It's a very interesting curve as it goes down to very low levels of offensive weapons.

Then what would happen? I think that people would begin to consider alternative nuclear delivery means. Certainly the Soviets are doing that; they are looking at means of providing deterrence other than ballistic missiles. Obviously, the solution is a human one. There is only one solution—the two societies must be willing to live together on the planet without trying to destroy each other.

I believe that the people who assert that partial defenses are useless or that a defense itself is destabilizing should at least be challenged in exactly the same way that the SDI is challenged. For example, while the OTA report spent a great deal of time dealing with the issues of whether strategic defenses would offer us a stable environment in the future, no part of that report dealt with a detailed examination of the alternatives.

QUESTION:

What effect will countermeasures against defensive systems have on the decision to deploy them? How about the decision to abrogate the ABM Treaty?

ABRAHAMSON:

Counter-measures against defensive systems.

I expect that the research will be successful, and at some point in time the United States will have to make a decision. Frankly, that decision will be very complex and technically esoteric.

Our leadership will have to take a look at and examine the ground-based lasers that we have built, for example. They will have to look at postulated countermeasures and see that the scheme we have developed is one where the fundamental physics and the fundamental engineering is on the side of defense. We are testing two sides of the issue. First, we are testing to see if a laser can destroy a missile. At the same time we're trying to find out if we can invent an armor that will be effective against reasonable size lasers. The assumption is if we can build that armor, then eventually the Soviets could too. So then the conclusion is, if a laser armor really can be invented and it is effective enough to stop a laser, then a laser is not a good weapon to use. That's why we're pursuing other paths as well.

Making a decision to deploy defenses.

The ABM deployment decision will be dependent on the world situation. Certainly it depends on the way the Soviets respond in the next few months and perhaps years in the present negotiations and on the progress that we're making on the technical side of the program as well. I have very little doubt that we will be successful in research, and then it'll be a matter of being able to understand that success in such a way that the decision-makers can make what will be a very complex decision.

QUESTION:

Could you tell us a little more about the extensiveness of the U.S. countermeasure and then counter-countermeasure effort?

ABRAHAMSON:

We are looking for areas where there is a fundamental advantage for the defense. For example, let me go back to the laser armor I just mentioned. If a foot thick of laser armor is sufficient to stop anything that the United States could produce, then the Soviets will see if they can put a foot thick of

that armor on their ballistic missiles without having to go back and widen every one of their missile silos. Maybe two feet is required. If they put on a foot of armor, we can just make the lasers a little bit more powerful.

There are a whole range of countermeasures including maneuvering, hardened satellites, laser armor, decoys, and active measures. They have to be thought through much more clearly and much more definitely, and we are doing that.

Session II
The U.S. Research Program

FIRST SPEAKER: GEROLD YONAS *(Chief Scientist and Acting Deputy Director of the Strategic Defense Initiative Organization)*

In a February 20, 1985, speech on the SDI, Ambassador Paul Nitze, special adviser to the President and the Secretary of State for Arms Reduction Negotiations, described a transition period from an offensive to a defensive strategy as a cooperative endeavor with the Soviet Union in which arms control would play a critical role. We would, for example, envision continued reductions in offensive nuclear arms. People ask the question, "Under what circumstance could such a cooperative transition take place?" Ambassador Nitze says that for such a cooperative transition to take place both the United States and the Soviet Union must see it in their own self-interest.

Certainly the United States wouldn't expect the Soviet Union to help us solve our problem. The Soviets complain about the fact that the SDI is expensive and won't work, but I doubt very much if they're just worrying about our national deficit. In fact they are probably convinced that research has shown that we can deploy, if we decide to do it, a system that could be survivable and cost-effective at the margin and that would really make it very difficult for them to continue their offensive buildup or hope to achieve any military goal by further investments in the offensive arena.

Countermeasures: the critical issue in SDI research.

The critical issue in the research program is the question of countermeasures. What will the Soviets do? The United States is pursuing a very active countermeasure program so that researchers will understand exactly what is required in the way of defensive sensors, battle management, and interceptors to convince the Soviets that deciding not to cooperate would not be in their best interests.

There are a number of important technology and scientific questions needing resolution as research

into strategic defenses goes forward. The first concerns data collection and processing. One measure of the relative importance of a program element is the budget allocated to it. If one sums the SDI budgets projected for the sensor program and the signal processing, battle management, and communications elements, one discovers that they comprise 40 to 50 percent of the total SDI investment over the next five years. Much of this data collection and processing technology probably would have evolved in the natural course of events, possibly over the next ten years, but the SDI has accelerated the process. We are investigating space-based sensors to detect and track the bright booster plumes,* as well as examining the cold post-boost vehicles and reentry vehicles. We are also investigating infrared sensors and laser trackers on aircraft to detect reentry vehicles late in the midcourse phase, the long period from post-boost to reentry. We hope that the trackers and sensors will also be able to discriminate, that is to determine which warheads are real and which are decoys or other nonthreatening objects. An airborne sensor platform is also likely to be the key to target tracking and discrimination for short-range missile defense. Currently we are trying to determine whether or not producing the sensors is feasible and how effective they might be in the face of countermeasures such as a nuclear disturbed environment or decoys used to confuse or saturate the data reduction and decision process.

Signal processing, battle management, and communications.

All effective defense systems involve multiple intercept layers and depend on the existence of a boost-phase layer to intercept the large-payload, slow-burning boosters that would otherwise be able to deploy practically unlimited numbers of objects during the post-boost phase. We must have a boost-phase layer to thwart proliferation of large payload boosters and force the Soviets to rely more heavily on faster, lighter, and thus smaller-payload boosters. Even given a highly effective boost-phase layer, however, we would still need a midcourse intercept

Multiple intercept layers.

*"Bright" plumes are easy to observe; "cold" are hard to observe.

capability. During midcourse we must face a plethora of objects from each post-boost vehicle that escaped the boost-phase layer of defense unharmed. Discrimination at the time of atmospheric reentry, or when the reentry vehicles and decoys are deployed, is made possible because of the perturbation provided in one case by the drag of the atmosphere, and in the other case, by the very act of deployment itself. By making precise measurements of object dynamics, one can get, in effect, a mass measurement. A laser radar using short wavelengths and reasonably sized optical instruments may permit such precise measurement over thousands of kilometers. With the shorter terminal-phase ranges, we will be able to obtain such data with microwave radar and ultra high speed data processing.

Electro-optical systems.

Most of these approaches require electro-optical systems to collect the light of a booster plume, the infrared signal from a cold body in space, or the reflected signal from a laser radar. In order to manufacture and deploy such a system, we will have to practically create an entirely new and advanced electro-optical detector manufacturing cap ability geared to high quantity production. We are going to have to invent techniques for rapid manufacturing of precise, but low cost, optical elements detectors and signal processors.

Cold target acquisition or detection hinges on cryogenically cooled arrays of long wavelength infrared detectors at the focal planes of the optical systems. In order to obtain sufficiently precise data on multiple objects we will need mosaics of these detectors at the focal planes that either stare simultaneously at the entire image or can scan repeatedly. In order to obtain high resolution, millions of elements will be needed in each focal plane array. Hence, the production of uniform, high quality detectors is receiving increased emphasis, and we hope to be able to produce large, high resolution arrays by the end of the decade.

Although we are emphasizing passive surveillance and discrimination techniques, we are aware that the Soviets could use countermeasures such as lightweight decoys to make it very difficult to succeed with these techniques. Taking this into account,

Interactive surveillance and discrimination techniques.

we are increasing our emphasis on methods to make it practically impossible to confuse the sensors with sophisticated decoys. We believe the ultimate answer to such a countermeasure is to employ "interactive" rather than passive observations. That is, to externally provide a mechanism to perturb the local environment of the decoys and reentry vehicles, and then observe their reaction to the perturbation. If one has control of not only the detector, but also the perturbation, there is less of an opportunity for the offense to confuse the defense. One concept for providing such a perturbation is to direct a laser beam or a stream of energetic atoms at the cloud of objects thrown out from the post-boost vehicles. The observable reaction would depend not on each object's construction, but on the mass of each of the objects, thus allowing meaningful and robust discrimination. The object would be to sweep through the threat cloud with the beam and label the heavy objects (the real warheads) so that they could be attacked with space based or ground-based interceptors.

The Homing Overlay Experiment.

The basic feasibility of space-based interception and destruction of a reentry vehicle was demonstrated in the June 1984 Homing Overlay Experiment. The interceptor's infrared sensor allowed it to detect, maneuver in front of, and collide—"home-in"—with the small cold reentry vehicle traveling toward it. That important accomplishment required the development of various key technologies: the radar tracker, the homing sensor, the data processor, and the thrusting engines. The experiment was a success, and now, having shown proof-of-principle, we must investigate miniaturization technologies that will permit low-cost production of ground-based interceptors. If we could accomplish midcourse discrimination and then develop a low cost, ground-based interceptor, we would have a robust, survivable, and cost-effective component of a multi-layered defense system that would in itself give us the first element of an effective defense of large areas.

In the terminal phase, there would be very little time (less than one minute) to reach the intercept altitude and maneuver in order to make a direct

collision. We are, therefore, investigating precision homing capability, but also a fused warhead to improve the kill probability with a near miss. A high explosive warhead would be detonated producing a focused shower of metal particles or debris that would destroy the incoming reentry vehicle. We are exploring how to operate in the nuclear environment that may arise from salvage fusing (a fuse that detonates when it is tampered with) and trying to develop a sensor window that can endure the effects of ascent heating. Again, cost is a dominant issue, particularly if large numbers of interceptors are required, as is the case with short-range missile defense.

Problems to solve . . .

. . . in terminal-phase interception,

If we pre-deployed small rocket-launched interceptors in space, interception would take place at relatively low altitudes and not only the reentry vehicles in midcourse, but also today's very slow Soviet boosters could be attacked. Indeed the prospect of such a boost-phase intercept might motivate the Soviets to initiate a costly and time-consuming effort to respond by developing, constructing, and deploying boosters and post-boost vehicles that complete their function in a considerably shorter time.

. . . and boost-phase interception.

We must, therefore, be prepared (not now, but likely some time after the year 2000) to deal with entirely new boosters and post-boost vehicles that could complete deployment in two minutes or less, rather than the present five or more minutes. In addition, the offense might be able to rapidly deploy multiple post-boost vehicles or reentry vehicles. In order to maintain the defense leverage by countering the booster itself, we would have to be able to deliver sufficient lethal energy to a large number of nearly simultaneously launched boosters while they are still within the atmosphere. We might be able to continue to use kinetic energy intercept weapons even against the fast post-boost vehicles, particularly if more advanced projectile launchers such as hypervelocity guns are developed; however, it is likely that the enduring function of kinetic energy intercept would remain in the midcourse phase. A robust boost-phase capability would require a speed-of-light weapon that can propagate energy through the atmosphere.

The chemical laser.

The most mature and conceptually simple weapon for boost-phase intercept is the chemical laser. It efficiently converts its chemical fuel supply into a powerful beam of light by mixing the stored reactants in a combustion chamber that also acts as the laser resonator. Its ability to focus its beam onto a one meter size spot thousands of kilometers away depends on the ratio of the diameter of the beam director to the wavelength of the light. If the wavelength is long, as unfortunately is the case with chemical lasers, the diameter of the beam director would have to be tens of meters. Thus, additional questions of cost and survivability would be raised. We are, therefore, investigating methods to make such large optical instruments possible through phasing together arrays of smaller elements and exploring other weapons that might operate at shorter wavelengths.

The most promising short wavelength lasers are the excimer and free electron lasers. (An excimer laser is a chemical laser that uses chemically inert gases; a free electron laser converts electrons to light.) They could be deployed in space but issues of efficiency, fuel supply, and maintenance have forced us to consider ground deployment. (One variation of the free electron laser would, however, be adequately efficient and lightweight to be space-based.) We are also considering the use of multiple, orbiting relay mirrors and fighting mirrors deployed in space to achieve global coverage with a relatively small number of ground-based lasers. A potential problem of the ground-based laser is the difficulty in transmitting light through both a clear atmosphere and during bad weather conditions. The solution to the weather problem is to employ enough ground stations in various optimally chosen locations to ensure adequate coverage under all situations. Nevertheless, a laser on the ground must transmit its beam through a layer of everpresent turbulence that would spread the beam over a very large region. We have now demonstrated a technique for correcting the beam to compensate for this turbulence and may also be able to use the same technique (called "phase conjugation") to build rather high-quality optical instruments using low-cost components.

Phase conjugation for atmospheric compensation.

In phase conjugation, a low power source of light is provided to transmit a high quality beam through the optical system to a detector that measures the distortion of the beam caused by the turbulence and the optical system. With a technique called adaptive optics, a deformable mirror whose shape is controlled by multiple, computer-controlled activators then imprints the inverse of that distorted waveform on the outgoing beam. After the beam has subsequently passed through the turbulence, it has in principle been fully corrected. Recent experiments on the ground with aircraft, and from ground to space, have shown the basic feasibility of phase conjugation for atmospheric compensation. Other methods for producing phase conjugation involve passing the beam that has been distorted by the poor optics into a "non-linear optical medium" that automatically produces an inverse beam. These techniques provide opportunities for greatly simplifying many of the most challenging optics problems we presently face.

Excimer lasers.

Of the two ground-based laser concepts, the excimer is the least expensive, but tends to be rather inefficient. The excimer laser operates by direct excitation of a gas medium with a high-powered electron beam. Since the lasing action is relatively inefficient, most of the electron energy heats the gas and disturbs the medium. Because the medium must be quiescent before the next pulse, the disturbance limits the pulse repetition rate. However, if a few or even one pulse could provide lethality, then the relatively slow rate of fire of the excimer laser would be acceptable. In order to evaluate this concept, we are studying not only laser technology but also the generation of high pressure shock waves and structural effects and the ability to protect an object from impulsive loads.

Free electron lasers.

The other short wavelength laser concept, the free electron laser, converts the energy from an electron beam directly into light without the use of an intermediate gaseous medium. In the excimer laser, the steps necessary to transfer energy to the gas and then convert it to photons and extract them, introduces losses. This results in low efficiency and a low pulse rate. In the free electron laser straightforward energy conversion results in high efficiency

and a high pulse rate. Free electron laser operation has been efficiently achieved at microwave frequencies. A major feasibility experiment, at both high-power and short wavelengths, and with adaptive optics for atmospheric compensation, is planned. If this approach can also be made lightweight enough for space deployment, it would offer ideal characteristics of cost, performance, and size.

Other issues related to beam propagation efficiency and scattering by the atmosphere are still to be fully resolved, and the optimum laser, whether in space or on the ground, is far from being chosen.

Booster hardening.

One of the factors governing this choice—or indeed whether lasers can truly fulfill our requirements—is booster hardening and laser lethality. The U.S. goal is to be able to evaluate the lethality of weapons against a wide range of hypothetical targets. At present we are carrying out subscale, as well as full-scale, tests under simulated flight conditions to determine the lethality of our weapons against unhardened boosters. We already know that the booster flight loads are heavy and that laser weakening of a structure can result in catastrophic failure. This and similar lethality issues for the full range of directed and kinetic energy weapons will continue to be dominant for the next few years.

In addition to understanding hardening of the offense and the lethality of defense weapons against a responding threat, we will certainly also have to investigate hardening limits of whatever we might predeploy in space. We must understand the survival requirements posed by a defense suppression attack. We are therefore investigating lightweight armor to protect our space platforms against kinetic and directed-energy attack, as well as to define the achievable hardness levels for boosters, post-boost vehicles, and reentry vehicles. If we are to have an effective and survivable system involving extensive space pre-deployment, we may require self defense of these assets. In that case, we will need to show that spacecraft could be substantially more survivable, at least in a functional sense, than attacking threats.

Computer software for battle management.

So far I have emphasized hardware, but we at the SDI Organization are also quite aware of the vital task of providing software for the battle management system. Clearly the size of the software is daunting, but very large software systems already do exist. The telephone switching system in the United States is already quite large (more than 10 million lines of code), although it has taken many years to evolve. Very large software systems can certainly be built for a defensive system. The question is whether or not we can build systems that are sufficiently flexible, tolerant of errors, and adequately testable and that can evolve with time.

Developing such software will be a difficult and time consuming job that must proceed before hardware definition is complete. We are thus likely to require ways to re-use and modify our evolving software (possibly using automatic techniques) as we test initial systems and learn from extensive simulations. To achieve adequate speed and flexibility, we may have to develop specifications for software based on logic and prescribed automatic approaches, rather than on present methods that are time-consuming and people intensive. More than likely we will need a highly-distributed information-gathering, processing, and decision-making system and will employ redundant techniques to provide a system that can continue to function in the face of errors or attack-caused failures. All of these considerations point to the immediate need to get on with specifying, writing, and testing the software. We expect to greatly enhance our initially inadequate emphasis on this aspect of the defensive system and accelerate the creation of a dedicated facility to develop, test, and integrate various battle-management software elements with both real and simulated hardware elements.

There are other so-called logistics issues that are just as essential as software, such as providing compact energy supplies for continuous and burst-mode space-based operations. Concepts under consideration include open-cycle chemical and nuclear systems, closed-cycle systems, and various hybrid approaches. One novel concept under study is to

employ an energy storage device, such as inertial storage, batteries, or capacitors, and a relatively low power nuclear reactor energy supply, say at hundreds of kilowatts, to provide station-keeping power and to maintain the stored energy needed for a battle. Because of the many applications considered for space nuclear power, we are proceeding now with a reactor ground-test facility in which we will employ a liquid metal heated thermo-electric converter, operating at 300 kilowatts, as our first step leading to a space demonstration in the early 1990s.

Lifting large payloads into space.

Another vital logistics issue in terms of cost is delivering unprecedented payloads into space. We are investigating the next step in space transportation to give us capabilities well beyond that provided by the Space Shuttle. Because the cost to lift is at present so large (over $100 million each launch), we are not only investigating heavy lift concepts that are derived from the Shuttle technology, but also beginning to explore totally new concepts involving reusable vehicles, which we hope might in the future allow us to reduce greatly the cost of lift. One such concept is the transatmospheric vehicle that would be based on hyper-sonic scramjet propulsion and advanced materials technology.

Although this accounting of technology is not complete, I have tried to emphasize many of the key technological barriers that must be overcome. It is conceivable that discoveries or breakthroughs could substantially change the prospects for a successful defense or the opportunities for the offense. In a true development program, it is practically impossible to achieve compliance with rigorous schedules and budgets if program participants continually introduce innovation and new approaches. On the other hand, in this research program, it is reasonable to expect and indeed vital to stimulate creativity to provide the basis for any development that may follow.

Within five years the United States will have the foundation for convincing the Soviets that a cooperative transition is in their interest as well as ours. This foundation will be built on the basis of the technologies which I have described. These technologies have near-term and long-term options

and offer the possibility of providing the requirements of cost-effectiveness and survivability. The role these technologies would play in negotiations would then lead to a transition process which would leave us with a safer and more secure world.

A cooperative transition possible in five years.

That cooperative transition, as I envision it, will be a carefully managed build-down in offensive forces and a managed buildup in defensive forces. Along the way, we will need to maintain stability in a crisis in case Soviet irrationality starts to expand on various fronts because of an international crisis. In other words, as we manage this transition, we have to be very careful about the way we balance our offensive and defensive forces. Negotiating the terms of the transaction will be long, complex, and difficult. Such negotiating is what we're engaged in right now.

SECOND SPEAKER: EDWARD T. GERRY *(President, W.J. Shafer Associates, Inc.)*

The original discussion of ballistic missile defense technology that occurred in the late 1960s and early 1970s led to the technical judgment that a robust, highly-effective ballistic missile defense was not possible. Only ground-based, essentially terminal defenses were under consideration, and ballistic missile defense capabilities of that period were relatively ineffective. An economic exchange which was favorable to the defense did not appear likely. On the technology side researchers have been trying to find out if anything has changed.

Technological innovations now make possible an exchange ratio favoring the defense.

The Fletcher panel found out that a lot has changed technologically that might affect the conclusions. First, from an architecture point of view, researchers are considering a multi-layered defense which attacks an ICBM and its payload throughout its entire trajectory. On the technology side, one of the major stumbling blocks that existed in the earlier debate was dealing with thousands of targets on a short time scale with the large inexpensive computer systems of the day. Everyone is aware of the revolutionary changes that have occurred in that field. A great deal of progress has been made in the area of sensors that operate at every wavelength throughout the spectrum. Space technology in

general has developed guidance and control capabilities to a very high degree of accuracy. The ability now exists actually to make non-nuclear interceptors that simply run into the target as a destruction mechanism. The earlier systems would have used nuclear intercepts. In the recent successful Homing Overlay Experiment demonstration and the anti-satellite test, non-nuclear hit-to-kill intercepts have been demonstrated as workable technology. In addition, advanced technologies, such as lasers and directed energy weapons, have developed rapidly. In my view, lasers will see early applications as sensors, designators, aids to discrimination, and probably only later, if it becomes necessary, as weapons. Lasers might be the answer to certain kinds of responsive threats, but they have major roles early on. The technology to support those earlier roles is much closer than the weapon-level lasers that people talk about.

High-leverage areas for research.

General Abrahamson discussed the importance of being able to destroy ICBMs in the boost phase where high leverage exists. To be most effective, the systems that carry out boost phase must have elements based in space, and the existence of those elements in space does raise issues of the survivability of those systems against an attacker and their cost effectiveness.

The architecture studies, which are ongoing elements of the SDI program, have also identified two other very high leverage areas. The first is early midcourse phase (from the time when the reentry vehicles come off the bus or the post-boost vehicle to the time when they can first be reached by a ground-based interceptor in the United States). That turns out to be a very long period of time—15 minutes or so—and turns out to be a region of engagement which can be addressed by space-based components. The second important high-leverage area is what we call interactive discrimination using the assets that we have in space to interact with things that might be decoys and to determine positively whether or not they are in fact live reentry vehicles. Those look like very promising techniques.

It is quite possible that the technologies being researched can lead to systems that might meet the criterion of survivability and cost effectiveness. A good example is the case of a space-based kinetic-energy weapon, which is a multi-staged rocket that is a terminal-guided homing kill vehicle.

Survivability.

Survivability means survival of the system function, whatever the system function is supposed to be in space. Of course nothing is absolutely survivable, but the question that must be asked is what price the defense must force the enemy to pay to negate a particular asset in space.

Ten to fifteen years ago when researchers looked at the space-based kinetic energy weapon, guidance systems were very poor, which meant that the warhead had to be very heavy. That led to very heavy rockets to boost it. In short, the whole system turned out to be very heavy, expensive, and inefficient. Now, however, developments in the tactical field—the smart rockets, the smart bombs, laser semi-active guidance—allow us to adapt that technology to a homing kill vehicle in space. The basic homing head for that sort of thing can be very light, on the order of a kilogram, and should cost less than $100,000 a piece. In other words the prospect exists for developing a space-based kill vehicle which is affordable and small enough to be put in space in large numbers.

Earlier plans called for very large platforms with large numbers of rockets on them, a very attractive target. Today the attempt is to limit how much is put on an individual platform; we envision perhaps ten kinetic-energy weapons on one platform and a thousand or more platforms. That system makes the value of individual platforms quite small and addresses to a great extent the capability of systems-level survival.

Let me finish with a very rudimentary look at the prospect for a favorable cost exchange. In other words, is the weapon cost effective? The ability of a space-based kill vehicle to attack a rising booster and its payload varies with the kind of booster and the mid-course trajectories on which it deposits its reentry vehicles. Studies give numbers that range

from two to four space-based kill vehicles in orbit for each reentry vehicle to be attacked. The exchange ratios are lower for some of the big, heavier, older missiles and are higher for the more modern missiles, but, nevertheless, the exchange ratios are in the range of two to four. Studies indicate that, with some of the technologies that are projected, one should be able to put a space-based kill vehicle in orbit for ten years with all the systems that maintain it for about $1.5 million per missile. That means that it costs anywhere from $3 to $6 million per reentry vehicle negated with these systems.

Prospects for a favorable cost exchange.

The other side of the question is how much it costs to deliver a reentry vehicle. Costs given range from $6 to $10 million to deliver a reentry vehicle for a large, land-based, heavily MIRVed missile to $30 million for mobiles and submarine-based missiles.

Given that simple one-on-one kind of exchange, the cost exchange certainly is in favor of the defense. A word of caution, however: the problem is much more complicated than my example. Any analysis of cost exchange ultimately will have to take into consideration air defense on both sides and many offensive and defensive systems. But certainly the numbers that have been looked at to date don't suggest that achieving a cost-effective-at-the-margin kind of system is an impossible dream. It certainly appears to be within the projections of the state of technology.

THIRD SPEAKER: PETER SHARFMAN *(Program Manager for International Security and Commerce Programs, Office of Technology Assessment)*

Several stages of technical effort must be accomplished before the United States will be able to deploy a strategic defense system that's worth having. The items which General Abrahamson and Dr. Gerry have referred to are components or subcomponents of such a system. They are the technological building blocks from which a system could be built.

The next, more difficult, stage is systems integration, which involves choosing an architecture for

the system. Engineers need to decide how the various pieces of the system will fit together and what the objective will be in each of the phases of the layered defense. For example, systems designers need to decide what kinds of sensors will be used to detect and track the enemy missiles, what data processing and communications systems will be required to get the necessary information to the appropriate kill mechanisms, and how all of the elements can be made to work together to fend off an attack. One isn't concerned with the survivability of individual pieces, but with the survivability of the function. If the defensive system as an entire system can do its job, it doesn't matter if some individual pieces of it are vulnerable. On the other hand, if the system as a whole cannot do its job, it doesn't matter that individual pieces may survive or may function beautifully.

Systems architecture now highest priority for the SDI program.

The systems architecture problem is the single highest priority of the SDI program now. Until that job is completed, until there are a few leading candidates for systems architecture, it isn't possible to make a judgment on whether or not the system is affordable, cost-effective, and stabilizing.

Questions about stability of BMD deployment.

General Abrahamson misrepresented the findings of the OTA report. According to him it stated that ballistic missile defense deployment would be unstable. What the report actually stated was that at this moment nobody knows whether this deployment would be stabilizing or destabilizing. One can identify a level of strategic defense which is quite effective, but not capable of shooting down *all* of a Soviet attack. If the United States were on its way to a nearly assured survival situation, this would be a transitional level, but the transition might take anywhere from a month to two decades. One doesn't know.

Our analyses at OTA show that at the intermediate level of capability there is a real question about stability. OTA found that until a systems architecture is settled upon and until, therefore, U.S. strategists have a pretty good idea of what the Russians might do in response, it is impossible to know whether a deployed system would be stabilizing or destabilizing. Just as Paul Nitze said, one ought to

know whether a system is cost-effective at the margin before deciding to deploy it. Similarly, one ought to know whether the transition period is safe or dangerous before deciding whether to enter it.

Protecting American assets.

The second major factor critical to a deployment decision is how to estimate the capability of a defense. One ought to think of a system not in terms of how many Russian reentry vehicles it can shoot down, nor in terms of how high a price it imposes upon the Soviet Union, but rather in terms of what American assets it can protect. That is really the payoff. If one can still conclude that the United States is protected after considering Soviet countermeasures, then the system looks like a pretty good idea. In contrast, if one concludes that an awful lot of complicated things have happened but the targets in the United States are still vulnerable to a Soviet attack, then that would raise a serious question as to what the United States had got for all the money spent.

There are two ways to protect an American asset targetted by the Soviets. One is to shoot down every Russian reentry vehicle that is coming towards it. The second is to create a situation where the Russians don't even bother to attack it because they feel that they must concentrate on a limited number of targets to feel confident of destroying any of them. So it's an oversimplification to say that if the U.S. ballistic missile defense protected many of the 10,000 American targets selected by the Russians, then the Russians could not achieve their objective and would be deterred by the United States. The correct way of looking at it is that a U.S. ballistic missile defense system would oblige the Russians to shrink their target list for any given Russian offensive force.

Possible Soviet responses to U.S. defenses.

Of course the Russians say they would increase their offensive forces to overwhelm U.S. defenses. But for any given Russian offensive force, their assessment of what the U.S. defense can do will lead them to settle on a target list that is larger or smaller depending on what can get through. If the Russians feel that to be sure of destroying a target, they must fire ten reentry vehicles at it because the United States will shoot down 90 percent, then the

Russians will develop their target list by taking their total number of reentry vehicles and dividing by ten. Then they'll start at the top with the most important targets and work down until they can't attack any more. One effect of a ballistic missile defense system, unless it is really a perfect one, is to shrink the Soviet target list. It is not a question of whether the Russians are deterred from a first strike because it can't succeed. It is a question of being sure that a first strike always looks like a lousy option to the Russians rather than a good option because of their assessment of what U.S. targets they could destroy.

Levels of effectiveness of a defensive system.

The next point to consider is the differing levels of effectiveness which a defensive system could have. Analysts need to ask which levels are useful to the United States, and then in turn to judge whether the system proposed for deployment is or is not good enough to buy. Of course, the simplest level is where the United States is now, which is no defense at all. That's easy to understand. The next level up is protecting many ICBMs and silos from a Soviet attack. General Abrahamson said that that wasn't the objective of the SDI program, but some of those who favor ballistic missile defense say that ICBM defense would be worth doing, at least as an intermediate objective.

A third level, much more difficult technically than defending ICBM silos, is forcing the Russians to shrink their existing target list of soft targets, be they military, economic, or population targets. If the United States creates a situation in which the Russians feel they can destroy some but not all of these soft targets, they have to concentrate their forces.

A fourth level is one in which U.S. defense is so good that the Russians must shrink their target list only to cities, which are the easiest targets to attack. In such a situation, the Russians would despair of successfully attacking military targets but would imagine that if they had 10,000 reentry vehicles and they targeted one hundred of them on each of the hundred largest U.S. cities, they could kill so many Americans and destroy so much of the American economy that they would at least have a deterrent. This level would be achieved if each side

had a defense that could shoot down perhaps 90 percent of the enemy's reentry vehicles. That level, ironically enough, would create a situation in which nuclear weapons were useful only for mutual assured destruction, which many people mistakenly believe exists today. The only thing nuclear weapons would then be able to do would be to kill the enemy population, but that they could do.

Finally, there is the level of an assured survival in which the population can be defended even against an all-out effort to attack it. The judgment reached in the OTA report, which I believe is fairly generally held, is that this level might be attainable if there were substantial reductions of offensive forces, but it could not be obtained if the Soviets were determined that it should not be.

Pacing of the overall program.

In addition to considering levels of effectiveness, another aspect of the U.S. research program to be considered is how the overall program should be paced. We at OTA are particularly concerned with this question, because it lies within the province of the Congress to determine the overall level of effort (i.e., how much money per year) and the general directions of the program, whereas details of what research to fund are best left to the Defense Department, acting on the recommendation of Gerry Yonas and of General Abrahamson.

Decisions to be made by Congress this year and in the years to come will have a major impact in either ratifying or re-directing a number of changes which have been initiated in the U.S. ballistic missile defense research program and in U.S. arms control policy by the SDI.

First, research under the SDI is intended to proceed at a "technology-limited" pace to permit a decision to be made at the earliest possible date on whether to enter full-scale engineering development; entering such development would clearly be inconsistent with ABM Treaty constraints. The pre-SDI program had no such mandate for an early decision on maintaining or abandoning the ABM Treaty.

Second, the SDI has much higher visibility and a much higher level of Presidential attention than the previous program of research in ballistic missile defense-relevant technologies. The decision to

spotlight ballistic missile defense has already been made, and its consequences are already being felt. These consequences certainly include a decision by the Soviets to at least explore their options to respond to the increased probability of a U.S. ballistic missile defense deployment.

Third, under the SDI, emphasis has shifted away from fairly well understood, or "mature," technologies, which generally include use of nuclear-armed interceptors, towards non-nuclear defenses, which would use much more speculative but potentially more powerful technologies.

Fourth, over the next decade, much more is to be spent on ballistic missile defense research than would have been allocated in the absence of the SDI. In the proposed FY 1986 budget, the ballistic missile defense funding level was more than twice its projected FY 1986 level under the pre-SDI program. Subsequent increases under SDI are to be even greater, and by FY 1990 are projected to be over eight times the FY 1984 funding level.

Finally, instead of the pre-SDI approach of seeking deep reductions of offensive forces along with maintenance of the ABM Treaty ban on defenses against ballistic missiles, current arms control policy seeks, according to what Paul H. Nitze stated in his March 28, 1985, address in London to the International Institute for Strategic Studies, "greatly reduced levels of nuclear arms and an enhanced ability to deter war based on an increasing contribution of non-nuclear defenses against offensive nuclear arms."

Three approaches to BMD research.

Different approaches to ballistic missile defense research proceed from different sets of basic assumptions about the value and feasibility of ballistic missile defense, and from differing assessments of the consequences of pursuing research into it. Three such approaches can be distinguished. They differ primarily in emphasis and urgency, rather than in which technologies are to be studied. Most ballistic missile defense-relevant technologies would be investigated, at some level, in all three.

The first approach is the SDI as proposed by the Reagan Administration. It involves vigorously investigating advanced ballistic missile defense

The SDI approach.

technologies with the intent to decide in the 1990s on whether or not to enter full-scale engineering development and subsequent deployment. This approach assumes that while technology now within the state of the art is not good enough to be worth deploying today, the potential of advanced ballistic missile defense technologies is sufficiently promising that a technology-limited effort (i.e., a program limited by what is technologically feasible rather than by funding constraints) is warranted to develop that potential. It also assumes that if successfully developed, such technologies could make possible a national security regime (weapons systems and arms control) preferable to the current one.

The early deployment approach.

The second approach is to emphasize early and incremental deployment of currently available ballistic missile defense technology. This approach places high strategic value on the modest levels of defensive capability which could probably be obtained today. Although the ABM Treaty permits the United States to defend some ICBMs with a single, highly constrained defensive deployment, most early deployment proposals go beyond these constraints and could not be pursued under the existing treaty regime.

Some proponents of this second approach would put the emphasis on research on ballistic missile defense technologies advanced beyond those available today but which, unlike many SDI technologies, might be applicable to deployments in the early to mid-1990s. However, investigations of longer-run technologies should not delay deployments in the nearer term.

The funding-limited approach.

The third approach is to investigate advanced ballistic missile defense technologies at a funding level well below that requested for the SDI and with a much-reduced sense of urgency. Like the SDI, this approach would focus on advanced technologies that may eventually make a highly capable defense possible. Unlike the SDI, however, it does not assume that we will know in a few years whether we can achieve that goal. The program would not aim towards facilitating a development decision at a particular time, nor would it include tests or demonstrations which might raise questions of compliance with the ABM Treaty.

A variation on this approach is to balance research in advanced ballistic missile defense technologies with the development of near-term deployment options which would include "traditional" ballistic missile defense technologies (nuclear-armed, radar-guided interceptors) of the sort specifically mentioned in the ABM Treaty. This program, conducted at a funding level well below that requested for the SDI, would aim to deter Soviet abandonment of the ABM Treaty; to hedge against future Soviet ballistic missile defense developments; to prevent technological surprise; and to investigate the long-term potential of advanced ballistic missile defense technologies. Like the funding-limited approach, it would not include demonstrations or development work which might raise questions of compliance with the ABM Treaty.

Discussion

YONAS:

An effective defense creates incentives for arms reduction.

Before we take any questions I would like to comment on Peter Sharfman's view of Soviet behavior. Peter said that if the United States had a 98 percent effective defense, the Soviets would target our cities. In my view, that's the last thing the Soviet Union would do. If we had a 98 percent effective defense against their ballistic missiles, I think they would look across the table and see a beautiful bargain. The value of our defense would be exaggerated in their minds and the value of their own missiles would be reduced. There would be strong incentives for the Soviets to reduce their ballistic missiles. A 98 percent effective defense would be the most powerful incentive for massive arms reduction the world has ever seen.

The logic presented fifteen years ago was that if we just agreed to have no defenses, there would be powerful incentives for offensive reductions. Well, that logic was wrong. I don't see what's wrong with my logic. Clearly the Soviets are flooding the world with propaganda and disinformation. But once they saw that the United States had a technological capability and the resolve to proceed with the SDI program, there would be a powerful incentive to arms reductions.

In my opinion there would be no military value for the Soviets to strike American cities. The response to that would be suicidal for the Soviet Union. Basically the United States wants to take out of the realm of possibility the notion of a first strike. These new weapons would be used primarily in a retaliatory mode. It's hard for me to understand how cruise missiles could be used as a first strike weapon. It would take a long time to overfly somebody else's territory. These weapons of retaliation instead put us in a posture where we can solve a potential crisis through negotiation and through diplomacy.

For the foreseeable future there will be ways for one country to do unacceptable levels of damage to some part of the population of another country. The question is, how can we create a stable and secure environment where destructive behavior becomes the least likely and not the most likely in a crisis. We want to avoid a situation where both sides continue to build offensive weapons with very fast reaction times, a situation in which both sides fear a first strike and vie to be the first to push the button. This kind of a future is extremely dangerous, and I believe that both sides have an incentive to move away from that.

QUESTION:

Need to overcome the three "Cs."

Let me raise a question about the three Cs, as I'll call them, that need to be overcome by the SDI program.

The first is computer capability. Do we have the computer capability required? Estimates indicate that about ten million lines of instructions might be needed for these computers to operate. Programming these computers without the prospect of completely debugging them may cause several complications.

Secondly, the SDI has to overcome Soviet countermeasures, including launch tactics, penetration aids, simply overwhelming defenses, missile hardening, etc. Can this be done with a high degree of assurance?

The third is cruise missiles. If we can successfully defend against ballistic missiles, what do we

need to do to defend against the other threat of cruise missiles?

YONAS:

Computer problems are being solved rapidly.

Certainly there will have to be a solution to the problem of computers. The hardware part of the problem is being solved faster than anybody would have predicted. Massive parallel processing, integrated microcircuits, and very small chips are bringing a solution to the problems of hardware.

There are potential problems with software, but some very large software systems are already operating, as I mentioned in my remarks. The software for a strategic defense system is complex and would take a long time to write, and, as yet, we don't have the architecture. It would be foolish to write the software for an architecture that may change. What we really ought to do is develop the automatic software writing and software engineering techniques so that the exact software can be written in one or two years using several hundred people. I think the prospects are very good that in the next five to ten years we'll have the software capability. The hardware will be there by then.

We're investigating the question of Soviet countermeasures, but in the end we have to have a technology which is so imposing from the point of view of its credible technical basis that the Soviets adopt it and do not fight it.

GERRY:

With regard to the computer problem, I believe the software issue and the battle management problem have been considerably overblown in the press. Yes, there are a lot of lines of code, but I think the example of the telephone system is pertinent. There are many small, fast-acting computer algorithms working in parallel and they're doing the same thing over and over and over again. In this sense the computers for a defensive system are like the small units that are part of the telephone system, linked together at the top. There are all kinds of checks and balances and alternative ways of doing things. So the model of a big monolithic system that does the entire 10 million lines of code

in one millisecond is just not the way to think about a battle management system. Rather it is a lot of independent systems doing repetitive jobs, tied together by the system's architecture.

SHAREMAN:

Let me make two points with regard to computers. First, it's generally understood that in the area of automatic data processing—hardware and software, and especially the ability to make use of distributed data processing—we're way ahead of the Russians and we are increasing our lead. So if you're concerned about the Soviet ability to build the kind of ballistic missile defense system that relies on this kind of data processing, however hard they've been working on the components, they're way behind on the battle management and system integration parts.

The debugging problem.

Second, what causes a lot of concern about computer software is not the ability to make the individual pieces. It's the ability to debug the system as a whole without having a war to try it out. It is the risk of there being some glitch in the way the whole system is put together which cannot be spotted by testing subcomponents. That doesn't mean, however, that it couldn't be very effective as a deterrent.

Finally, I would call attention to the fact that in the area today of air defense, it is likely that the Strategic Air Command (SAC) thinks our bombers would penetrate more effectively than the Soviet Politburo thinks they would. It is possible to have a situation in which each side has a higher view of its own capabilities than the other side does, as well as a situation in which each side makes the worst case assessment.

Session III
The Soviet Research Program

FIRST SPEAKER: LAWRENCE K. GERSHWIN
(National Intelligence Officer for Strategic Programs, Central Intelligence Agency)

Soviet commitment to defense is long-standing.

We are concerned about the Soviets' longstanding commitment to strategic defense, including an extensive program to protect their leadership, their potential to deploy widespread defenses against ballistic missiles, and their extensive efforts in directed-energy weapons technologies, including high-energy lasers.

Their vigorous effort in strategic force research, development, and deployment is not new, but is the result of an unswerving commitment for the past two decades to build up and improve their strategic force capabilities. Soviet leaders are attempting to prepare their military forces for the possibility that they will actually have to fight a nuclear war. They have seriously addressed many of the problems of conducting military operations in such a nuclear war, thereby improving their ability to deal with the many contingencies of such a conflict.

We judge that the Soviets would plan to conduct a military campaign that would seek to end a nuclear war on their terms—by neutralizing the ability of U.S. intercontinental and theater nuclear forces to interfere with Soviet capbilities to prevail in a conflict in Eurasia.

Soviet active and passive strategic defenses, while unable to prevent large-scale damage from a major attack, are intended to provide a degree of protection for the leadership, military, and military-related facilities necessary for wartime operations. The

*Mr. Gershwin spoke to the symposium on an off-the-record basis. The material covered in his presentation was similar to his testimony before the Subcommittee on Strategic and Theater Nuclear Forces of the Committee on Armed Services and the Subcommittee on Defense of the Commmittee on Appropriations, United States Senate, June 26, 1985. This text consists of portions of his testimony, along with selections from the Senate question and answer period.

Soviets will significantly improve the capabilities of their strategic defenses over the next ten years.

The improved Moscow ABM system.

The Soviets have actively engaged in ABM research, development, and deployment programs for many years.

When completed by about 1987, the improved Moscow ABM system will consist of 100 silo-based high acceleration missiles and modified Galosh interceptors providing an improved intercept capability against small-scale attacks on key targets around Moscow. By the end of the decade, when a new network of large phased-array radars—including the Krasnoyarsk radar—is expected to be fully operational, the Soviets will have a much improved capability for ballistic missile early warning, attack assessment, and accurate target tracking. These radars will be technically capable of providing battle management support to a widespread ABM system, but there are uncertainties about whether the Soviets would rely on these radars to support a widespread ABM deployment.

The SA-X-12, a surface-to-air missile, to be deployed in the Soviet ground forces in 1985-86, can engage conventional aircraft, cruise missiles, and tactical ballistic missiles. It could have capabilities to intercept some types of U.S. strategic ballistic missile reentry vehicles. Its technical capabilities bring to the forefront the problem that improving technology is blurring the distinction between air defense and ABM systems. This problem will be further complicated as newer, more complex air defense missile systems are developed.

Potential for widespread Soviet ABM deployments.

We are particularly concerned that the Soviets' continuing development efforts give them the potential for widespread ABM deployments. The Soviets have the major components for an ABM system that could be used for widespread ABM deployments well in excess of ABM Treaty limits. The components include radars, an above-ground launcher, and the high acceleration missile that will be deployed around Moscow. The potential exists for the production lines associated with the upgrade of the Moscow ABM system to be used to support a widespread deployment.

We judge they could undertake rapidly paced ABM deployments to strengthen the defenses at Moscow and cover key targets in the western U.S.S.R. and to extend protection to key targets east of the Urals, by the early 1990s. In contemplating such a deployment, however, the Soviets will have to weigh the military advantages they would see in such defenses against the disadvantages of such a move, particularly the responses by the United States and its allies.

Soviet space program largely military.

The vigorous Soviet space program is predominantly military in nature. More than 70 percent of Soviet space missions are for military purposes only, with much of the rest serving a dual military-civil function. The Soviets view space as an integral part of their overall offensive and defensive force structure, not as a separate arena or as a sanctuary. While the Soviets seek to be able to deny enemy use of space in wartime, current Soviet antisatellite capabilities are limited and fall short of meeting this apparent requirement.

Today in addition to the dedicated nonnuclear orbital interceptor, other systems—the nuclear Galosh ABM interceptor and two ground-based high-energy lasers—have the potential to destroy or interfere with some satellites in near-earth orbit, but the potential threat to satellites in higher orbit is limited. It is likely that the Soviets would attempt to destroy or interfere with U.S. satellites during an intensive conventional conflict and in the initial stages of a nuclear war. These capabilities, however, would not survive a nuclear attack. Some improvement in Soviet antisatellite capabilities are expected.

Soviet efforts comparable to U.S. SDI.

Some of these systems are comparable in some respects to the U.S. SDI Program.

Directed-energy and kinetic-energy weapons potentially could be developed for several strategic weapons applications—antisatellite (ASAT), air defense, battlefield use, and, in the longer term, ballistic missile defense.

There is strong evidence of Soviet efforts to develop high-energy laser weapons, and these efforts have been taking place, in some cases, since the 1960s. We estimate a laser weapon program of

Soviet efforts to develop laser weapons.

the magnitude of the Soviet effort would cost roughly $1 billion per year if carried out in the United States. Two facilities at the Sary Shagan test range are assessed to have high-energy lasers with the potential to function as ASAT weapons.

We are concerned about a large Soviet program to develop ground-based laser weapons for terminal defense against reentry vehicles. There are major uncertainties, however, concerning the feasibility and practicality of using ground-based lasers for ballistic missile defense. We expect the Soviets to test the feasibility of such a system during the 1980s, probably using one of the high-energy laser facilities at Sary Shagan. An operational system could not be deployed until many years later, probably not until after the year 2000.

The Soviets appear to be developing two high-energy laser weapons with potential strategic air defense applications—one ground-based and one naval point defense. The Soviets are continuing to develop an airborne laser. Soviet research includes a project to develop high-energy laser weapons for use in space. A prototype high-energy, space-based laser ASAT weapon could be tested in low orbit in the early 1990s. Even if testing were successful, such a system probably could not be operational before the mid-1990s.

The Soviets are also conducting research under military sponsorship for the purpose of acquiring the ability to develop particle beam weapons. We believe the Soviets will eventually attempt to build a space-based particle beam weapon, but the technical requirements are so severe that we estimate there is a low probability they will test a prototype before the year 2000.

The Soviets are strong in the technologies appropriate for radio frequency weapons, which could be used to interfere with or destroy components of missiles or satellites, and we judge they are probably capable of developing a prototype radio frequency weapon system.

We are concerned that Soviet directed-energy programs may have proceeded to the point where they could construct operational ground-based ASAT weapons.

The Soviets have expended significant resources since the 1960s in R&D on technologies with potential applications for hypervelocity kinetic-energy weapons.

Soviet concern about U.S. SDI.

We believe the Soviets are determined to prevent any erosion of the military gains the U.S.S.R. has made over the past decade. They recognize that new U.S. strategic systems being deployed or under development will increase the threat to the survivability of their silo-based ICBM force, complicate their antisubmarine warfare efforts, and present their air defense forces with increasingly complex problems.

By their actions and propaganda, the Soviets have demonstrated they are very concerned about the U.S. SDI and its focus on advanced technology. In their view, it could force them to redirect their offensive ballistic missile development programs to reduce vulnerabilities or could stimulate a costly, open-ended high-technology competition for which they probably are concerned that the United States can outpace their own ongoing efforts. They are probably also concerned that SDI will lead to a sustained U.S. effort in strategic defenses.

SECOND SPEAKER: SAYRE STEVENS *(President of the National Security Research Group, Systems Planning Corporation)*

Differences in U.S. and Soviet approaches to strategic defense.

The thing that delights me most about this whole SDI debate is that the United States, which has for years eschewed strategic defenses of any sort and has never been able to maintain any that were developed, has now clutched the idea to its bosom. The United States now feels absolutely assured that it can go out and get a strategic defensive system that will change the nature of the world. The Soviets, for their part, have been committed to strategic defenses ever since the end of the Second World War. They have put a tremendous amount of effort into them, have had remarkable success, and have built a system by accretion through sheer relentless determination over the years. Ironically, they're the ones that are throwing out all the skeptical remarks about what can be done with strategic

defenses in the future. Neither of these inconsistencies, of course, is quite so outrageous as it seems.

The Soviets do indeed see strategic defenses as an essential element of their ability to deal with the whole problem of nuclear war. These are not just active defenses of the type that we're talking about today; they include passive defenses as well, such as the ability to use their offensive weapons to kill U.S. ICBMs and silos if necessary. And the Soviets have in their arsenal a full set of devices which will enable them to limit the damage that's caused by nuclear war should it occur. I think it's clear that they have no desire whatsoever for it to occur, but they recognize the possibility that it might indeed happen; and the military, who tend to define doctrine in the Soviet Union, has the responsibility for ensuring that if it does occur, they will live through that experience and come out in the best possible shape. They have taken all these measures with that purpose in mind.

U.S. and Soviet views on effectiveness of defenses.

No one of these individual Soviet defense systems solves the problem as a whole. There isn't one of them that's going to do 98 percent of the job or anything like that. But in the Soviets' view, doing 5 percent of the job has value. They're going to put all of those 5 percents together and develop a system that protects certain elements of society more adequately than others. They are seeking a capability which they hope they'll never need, but one that will enable them to keep the system functioning even in the event of a nuclear war.

The United States wants a strategic defense to be cost effective and to do 100 percent of the job. The U.S. view is that if a defensive system can't defend all the babies in the United States, there really is no point in having any defenses at all. That's the way we Americans behave. It's our choice. Nobody imposed it upon us. It's not the result of the ABM Treaty or anything else. We had an ABM system for one day and then discarded it because it wasn't cost effective and we could see no value in it. Now we find ourselves whimpering about the asymmetry that exists between the Soviet Union's defensive position and ours.

U.S. and Soviet weapons acquisition programs differ.

A part of the asymmetry results from substantial differences that exist in the weapons acquisition programs in the Soviet Union and the United States. When we Americans have had the will to develop something new, generally speaking, we have been able to cope with the technological problems. But lately it is becoming more difficult for us to cope with all the adversity and the setbacks and the costs that are associated with achieving technological triumphs, and so we find it harder and harder to do. Clearly all of the publicity and the big send-off for the SDI represents an attempt to build up that kind of temper in the people to go and take on this challenge— something like landing on the moon— that will enable us for once to get through this whole program and see it to its end.

The Soviets, on the other hand, have a system in which military requirements pretty much define what new weapons will be acquired. They invest heavily in the capability to develop and produce weapons, and they don't fall apart when a program is cancelled. Their capacity to produce new weapons systems is continually growing as new programs enter the process. They have momentum and a relentless approach. Their strategic defense program has been in existence for a long time and it has been proceeding with vigor. There's nothing wrong with that. Both the United States and the Soviet Union stated at the end of the negotiations that led to the ABM Treaty that they would continue to do R&D on ABM systems. Both countries have continued with such R&D, but the United States has done it with far less enthusiasm and vigor and commitment than the Soviets. Once again, that's our choice.

Needed: the will to see SDI through to the end.

These differences between the two countries are cause for some concern. SDI is, after all, a long-term, uncertain, costly, not totally attractive program that the United States is undertaking. I am very nervous about the ability of the administration to maintain the will of the people over the long haul that will be required. The United States is a great sprinter but not so good in the long races. The Soviet Union, on the other hand, has behaved in

precisely the opposite way. It has developed systems; it has slowly given them increasing capabilities, and through this process of accretion has finally reached a point where it has systems that are truly capable. In a sense, that's how a defensive system is going to come into being. It seems to me that the Soviets are in far better shape than the United States to undertake that job, unless the United States truly can find a consensus and develop a will within the people to stick through this from beginning to end. At the end of this pursuit of SDI I don't want to find the Soviets with a system while we have none at all. If that were to happen, I am not so sure that the Soviets would come over and give us a hand and straighten out all our problems and provide us with the technology that's going to let us get even.

DISCUSSION

QUESTION:

Current U.S. BMD capability.

In testimony before Congress on March 23, 1983, Robert Cooper, director of the Defense Advanced Research Projects Agency (DARPA), stated that in the exotic ballistic missile defense area, the U.S. program was sufficient to hedge against and in fact could probably in certain instances beat out the Soviet decision to deploy. In its September 1985 report and in testimony before the Foreign Relations Committee the OTA says that the United States has a program across the board from traditional to exotic ballistic missile defense systems which would allow the United States to excel over Soviet efforts should there be an arms race in this area. The Senate Foreign Relations Committee came to basically the same conclusion: the United States has sufficient ballistic missile defense capability to hedge against a Soviet breakout. Do you agree with these conclusions?

STEVENS:

There is a good deal of concern that the Soviets, because they have put so much effort into the development of conventional systems, are in a position to be able to deploy those relatively quickly and exclusively. I do not believe we have a hedge

against that. We do not have the capability to deploy a comparable ABM system, which is not the first requirement in any event. I don't think we even have the capability to respond in terms of protecting our offensive forces so that they can cope with the threat of the ABM X-3 or a whole slew of SAX-12s.

QUESTION:

Are the Soviets likely to deploy an ABM system in the near future?

GERSHWIN:

Soviet potential for ABM system deployment.

We have in our national estimates recognized for a number of years certainly the Soviet potential for ABM deployment. We have represented that in what amounts to a warning of concern.

We have very strongly noted their potential, watched it very carefully, and attempted to evaluate the implications and how fast it could be installed. But at no time have we judged that it is "likely" that the Soviets would in fact move out to such a deployment in the near term.

We have evaluated that by the early 1990s, based on our understanding of where the Soviets are, they could have in place a fairly large ABM deployment, but that is not a prediction that it is in fact what is taking place.

QUESTION:

You mentioned that the Soviets are carrying out a billion-dollar-a-year effort. Can you give some details on that?

GERSHWIN:

I want to make a cautionary statement that the billion-dollars-a-year estimate is an estimate based on our understanding of their laser program alone. It does not include their efforts in particle beam, radio frequency weapons, ground-based ABM, and conventional-type ABM, which is a substantial effort.

Certainly much of the laser program goes back to the 1960s, shortly after the laser was invented. The Soviets recognized in the sixties the possibility that lasers could have application to ballistic missile defense. They had a quick recognition of that. The

Soviet R&D in strategic defense goes back 20 years or more.

particle beam weapon research certainly goes back into the early 1970s. The radio frequency weapon research goes back to the 1970s. On the conventional ABM effort the Soviets go back to the beginning of essentially the nuclear age practically.

The Soviets were actively involved in antiballistic missile research and development in the late fifties and early sixties. They have had many different attempts at it, some of that leading to, in fact, the Moscow ABM system that the Soviets deployed which was constrained by the 1972 ABM Treaty.

But the Soviets' interest in strategic defense goes back to the beginning of Soviet military efforts. Interest in ballistic missile defense started at the beginning of the missile era.

They have essentially objected to our pursuing the options that the United States has described for the SDI program. For those types of research efforts the Soviets themselves have a very active research program of their own. That is not simply pure research.

Certainly we can look at the laser programs and recognize the attempt to develop weapons out of the program as part of the effort. It is not just an offshoot, but focused on that objective.

I mentioned that the Soviets have a lot of effort that we can recognize for ground-based high-energy lasers. We expect to see some of that tested in a feasibility test sometime in this decade through what they have in existence at Sary Shagan. That is happening now.

QUESTION:

What is the gap between the United States and Soviets on laser systems?

GERSHWIN:

U.S. and Soviet laser programs not comparable.

Let me comment in this way. The Soviets are pursuing some areas in high-energy lasers that we do not in this country pursue and vice versa. So, the programs don't match up one for one. We and they both work on some similar types of high-energy lasers with potential for anti-satellite, or whatever.

Some Soviet efforts are in areas that we in this country are not pursuing or have worked on and left for one reason or another.

One thing is evident. That is, the Soviets will in fact work on any area we appear to be making progress in because they themselves view the potential for the United States to do better than they can. They simply cannot afford, from their point of view, to have us pursuing some high-energy laser technology that they themselves were not able to do at that time. They have to pick it up from now on.

But they will continue to work on the areas they have been doing as well.

QUESTION:

Are there radars besides the one at Krasnoyarsk that would tie into a Soviet ABM system?

GERSHWIN:

Soviet phased-array radars.

Yes, we see a set of large phased-array radars of which Krasnoyarsk is a member of that set, and there are some six radars of that type either operational or under construction. The Krasnoyarsk radar is very similar to the other five that we are talking about. These radars are an improvement over the earlier Henhouse radars that the Soviets fielded much earlier and that have a number of functions. We would expect the Krasnoyarsk-type radars to have a number of functions, primarily ballistic missile detection and tracking, which means looking at reentry vehicles outside the atmosphere and tracking them as they go down toward the Soviet Union.

Within that ballistic missile tracking function is early warning, which is called ballistic missile early warning, which provides warning to the Soviet Union that they are under attack. That kind of warning function would lead to the Soviet decision to do something.

In addition, that type of information, if the radars are technically suitable and capable, could be used to feed an ABM system, if there were an ABM system deployed, to attempt to engage those reentry vehicles quickly before they actually come in and attack the target.

QUESTION:

Is the Krasnoyarsk radar capable of being a portion of a battle management system which would support an ABM system of a territorial nature?

GERSHWIN:

Yes, we see that as a technical capability because we expect the Soviets to have that technical capability in these radars. At the moment and certainly the near term, we don't expect to see that nationwide ABM system there. These radars could in fact be very useful and important, and we think would be important to the Soviet Union simply for their early warning function alone.

QUESTION:

Is the Krasnoyarsk radar a violation of the ABM Treaty in terms of its location?

GERSHWIN:

It is located further inside the Soviet Union, and it faces essentially in the wrong direction for it to have been allowed by the ABM Treaty, given that it is our assessment that it is for the purpose of tracking ballistic missile reentry vehicles.

Function of the Krasnoyarsk radar.

Whether or not there is a nationwide ABM system for this thing to feed is not the issue for the ABM Treaty. The ABM Treaty forbids a ballistic missile early warning function for this radar if it is to be in that location. It can only be in that location and orientation if in fact it has another purpose such as space tracking or for national technical means of verification.

The Soviets have stated it is for space tracking. It is our judgment it is for ballistic missile detection and tracking. That is based on a very careful, thorough body of work done by the entire intelligence community on this matter.

It does not, however, mean that necessarily the Soviets intend to have a nationwide ABM system as a result.

QUESTION:

Could you comment on the technological capability of the Soviet systems as far as computer capacity is concerned?

GERSHWIN:

Soviet computer capability.

A little bit. One of the issues about capacity has to do with the network of radars.

One of the most important aspects of potential for such radars to serve for battle management is the computer capability on the ground associated with those radars to process information they collect and sort it out in such a way that it can be usable quickly and accurately by an ABM system.

It is our assessment that the Soviets are technologically capable of having that type of computer capability for these radars. However, the Soviets have a lot of serious limitations in their computer capability. They are certainly limited in many aspects of computers, especially for the nonmilitary part of the country.

For these kinds of functions we are describing and the time period we are looking at, it is our assessment that the Soviets have the basic computer capability. Whether that computer capability is fully realized is another issue. That is not easy to tell because technological capability to have computers to do certain things and the actuality of that can be different.

QUESTION:

Dr. Gershwin, do the Soviets believe or adhere to a mutual assured destruction approach to nuclear war?

GERSHWIN:

Soviet view of mutual assured destruction.

While the Soviets believe that the destructive effects of a nuclear attack on their homeland would be a catastrophe, they do not accept mutual assured destruction as an operating principle for the development of their strategic force posture. They have consistently invested as much in strategic defense as they have in strategic offense. In their view, it is possible that nuclear war could occur. Their emphasis on strategic defense and command and control hardening has, in their view, the effect of enhancing the survivability of key elements of Soviet war-fighting capabilities, in the event of nuclear war, thereby enhancing their chances for prevailing.

QUESTION:

Could the Soviets use their Moscow ABM system to protect several key military assets?

GERSHWIN:

The improved Moscow ABM system of 100 silo-based interceptors will increase their capabilities to defend against small-scale attacks on key targets around Moscow, but would ultimately not be effective in defending against a large-scale attack against key targets in Moscow. Such an attack, however, would require a greater number of warheads to assure a high degree of success than if the targets were undefended, and would require using some weapons to attack key elements of the ABM system.

QUESTION:

Dr. Gershwin, you stated that you are concerned about the Soviets' longstanding commitment to strategic defense. Precisely why are you concerned?

GERSHWIN:

Soviet commitment to strategic defense is cause for concern.

The Soviet efforts are indicative of a Soviet attempt to prepare for the possibility of actually fighting a nuclear war. The Soviets' commitment to strategic defense has been sustained over many years, and is an integral part of their overall strategic force posture. If the Soviets come to believe that their strategic defense efforts would enable much of their key leadership and military forces to survive a nuclear attack, and they believed that they had an advantage as a result, it could embolden them to take greater risk in a crisis situation, and their perception of an advantage could embolden them to be more assertive in their foreign policy.

QUESTION:

Will the Soviets change their mix of forces in response to the SDI?

STEVENS:

At this stage of the game, I'm skeptical that the Soviets are going to change the nature of their forces in any very rapid way in response to the SDI. The future of the SDI is uncertain and the

Soviets are working hard to try to kill it before it gets underway. Killing the whole SDI program is their first best countermeasure. So I think it's very difficult for them to decide at this point what steps to take in modifying their forces to counter SDI.

Session IV
Arms Control Implications

FIRST SPEAKER: GERARD C. SMITH *(President, Consultants International Group, and Chairman of the Board, Arms Control Association)*

I would like to touch on four aspects of SDI and arms control: the ABM Treaty, the Geneva negotiations, the so-called transition that we have heard a good deal about recently, and finally the situation with regard to SALT II.

Interpretation of the ABM Treaty.

On the ABM Treaty, it is our conclusion in the Arms Control Association that the United States is living up to the treaty at present, but the prospect for compliance is not good in 1988-1989, and certainly the full SDI cannot be carried out consistent with the treaty. The Congressional OTA study was categorical on that subject. Recently there have been a lot of interesting gyrations about the ABM Treaty and how it should be interpreted. It reminds me of the famous Coca-Cola switch. We were told there was a new formula, but we are going to live up to the old formula. That whole episode does not speak well for the mission of U.S. negotiators in Geneva to stop erosion of the ABM Treaty.

Treaties are supposed to have an element of predictability, but the way the things now stand, who knows? The United States will live up to a restrictive interpretation but does not know for how long. Presumably if the new interpretation is legally correct, it will open the door to the Soviets to do a lot of things that I trust we Americans do not want them to do.

The new ABM Treaty interpretation supposedly frees the United States to do a lot of testing and development on so-called "exotics." In fact, this new interpretation probably permits the United States to build defensive systems as long as we do not deploy them. Some people say that we could even deploy new systems in test ranges and still be in conformity with the treaty. That shows what extremes this sort of interpretation can lead to. I think

that somehow the United States has got to go back to the old interpretation and perhaps even further. I am not sure that even the old interpretation is completely correct—but it is certainly a lot better than the new interpretation.

SDI and the Geneva talks.

As far as the Geneva arms control negotiations are concerned, the United States is probably coming up to the first "demonstration." First, a demonstration of how accurate the calculation was that the Soviets would cooperate with us in trying to get a new element of defense into our force mix. The President said that the SDI would help us achieve arms control. I respectfully disagree. I think it has already been demonstrated that the SDI is hurting arms control. Furthermore, the events of the next few months will demonstrate that the Soviets are not about to cooperate with us. In fact, the whole program can be simply described as follows: we are going after a radical new strategy, with technologies that do not exist, under a treaty interpretation that is far-fetched. For its effectiveness, the program requires cooperation from the Soviets. I cannot recall our ever launching a weapons program that required Soviet cooperation to help us out. As a matter of fact, this morning as I have listened to descriptions of what the Soviets are doing in the defense field, I have said to myself, "Why in the world are we ready to make deep cuts in our offensive systems when we face that tremendous Soviet defensive build-up?" Perhaps sometimes we do not believe our own rhetoric.

We claim to have brought the Soviets back to the negotiating table via the SDI, and I think there is a good deal in that proposition. But now that we have them back at the table, what is our position? Are we telling the Soviets to come back in ten or twenty years when we have developed defenses and when they have developed them, and then we will negotiate about some sort of a transition? That is not a very sensible approach.

As far as the transition to strategic defense is concerned, it seems that this is simply an engineer's wishful thinking that the Soviets ought to see that their interest lies in cooperating with us. I don't know of anybody who has worked with the Soviets

The transition to strategic defense—a "tricky matter."

who really believes they are going to see the light and decide to cooperate with us just because we have demonstrated a certain capability. This is similar to what we believed during SALT I. Then we believed that the Soviets ought to realize that limiting heavy ICBMs was in the common interest. We lectured them at length, but they in effect said, "No." I think that is what they will say about this new notion of integrating defensive and offensive systems.

Not much is said about how to verify a transition agreement. The problems of verifying limits on ICBMs, SLBMs, and heavy bombers are great, but it will be even more difficult to verify switches in levels of defenses and offenses. We will have great problems concerning what is left after ballistic missiles are impotent. How can cruise missiles launched from submarines be verified? A lot of work ought to be done now quickly on how to verify the transition before we get very far into it. I agree with Paul Nitze's characterization of this as a "tricky transition." I think the OTA properly described it by saying nobody has suggested how to go about designing the architecture of this new stage. I think the architecture of strategic defense is probably much clearer now than the architecture of the transition phase.

The SDI and SALT II.

My final point concerns the future of the SALT II regime. This issue will come to a head soon. If the United States decides on some sort of proportional response to claimed Soviet lack of fidelity to the treaty, hopes for a post-summit arms control negotiation will be torpedoed.

Unless there is some back-channel negotiation going on that most people do not know about—and I would not rule that out—the prospect for any significant arms control progress at the summit is minimal. The position that I took with several others in our *Foreign Affairs* article last year—that the Administration can have arms control or it can go for strategic defense, but it cannot have both—still holds up very well.* What the United States

*McGeorge Bundy, et al., "The President's Choice: Star Wars or Arms Control," *Foreign Affairs* 63 (Winter 1984-85), p. 264.

ought to be doing is lowering its sights. Instead of saying we are going for 50 percent reductions in offensive strategic weapons, the first thing to do is to clean up the existing mess. We say the Soviets are cheating on existing agreements. They say we are cheating on them. How are we going to make a new deal that the people of this country will support unless we first step up to the existing situation? Are the Soviets going to decommission Krasnoyarsk or stop working on it? What are we going to do about radars that we're building that the Soviets say are inconsistent with the ABM Treaty? What about Soviet encryption of telemetry? Can we work on a new deal with them without changes in their behavior? Probably not. So I would say the first thing that we ought to do is to tighten up the ABM Treaty. We should start by signalling our interest in cleaning up the existing situation, rather than proposing a utopian blueprint for the future. If something like that could come out of the summit meeting, there would be a prospect of getting on with arms control.

SECOND SPEAKER: DAN QUAYLE *(U.S. Senator from Indiana)*

The SDI is in the national interest.

I will focus my remarks on the inter-relationship of the SDI to our national security, the ABM Treaty, and arms control. I believe very strongly that the SDI is in our national interest and that we should, in fact, pursue it.

First, there's really no way that we can effectively cope with the Soviet Union in the area of offensive nuclear weapons, particularly new offensive weapons that have mobility, simply by building more missiles of our own. Some people argue that the answer is to build a mobile missile of our own. But it is unclear if the United States can. Certainly, the Soviets do not have the public or the environmental concerns to deal with as we do. More important, if we cannot find Soviet mobile missiles and command centers, it is unclear what our missiles would be targeted against, assuming that they survived a Soviet strike. Certainly, we need to consider some alternatives to the existing strategic

balance rather than placing all of our eggs in the offensive weapons' basket.

The SDI: an alternative to the existing strategic balance.

Second, the SDI could help our military assets, such as the MX missile. It may help us to move away from the use-it-or-lose-it hairtrigger situation that many people believe we now face, and towards a more stable strategic solution that would discourage the Soviets from contemplating a first strike. We are fearful of a first strike, and therefore the policy of deterrence must work. It has worked, but it can work more effectively with a better balance between offensive and defensive capabilities. In World War II, British Prime Minister Winston Churchill's investment in radar and interceptors was very effective against the early superiority of the German air force. It was a defensive response to an offensive threat. Why should it be any different now? We are faced with an offensive threat. Why shouldn't we contemplate a defensive response?

The Soviets have their own SDI.

Third, there's no doubt that the Soviets are vigorously pursuing their own strategic defense initiative. They have about 10,000 people involved in their high-energy laser effort. In a speech on June 28, 1985, to the Chautauqua Conference on Soviet-American Relations in Chautauqua, New York, Paul Nitze showed that it is simply untrue that only the United States is developing strategic defenses. The Soviet Union has been pursuing defense efforts of their own for quite some time. They have invested heavily around Moscow. They have a tremendous capability in air defense and their own ATBM system. They have invested more in defense than in offense. To think that U.S. restraint can prevent the Soviets from moving into the defensive area, then, is most unsound. The question is how are we going to pursue strategic defenses?

The future uses of space.

Finally, we have to confront the question about the future uses of space. For many years we have assumed that space might be used briefly by missiles but that it was not the arena in which there would be sustained conflict. This is changing, and we are now confronted with a new situation. We're not exactly sure what technology will bring, but

technology is really our strong suit. When free enterprise and freedom are unleashed, I believe we can utilize space to promote peace, stability, and a viable deterrence. And if we don't go forward, certainly the Soviets will.

The SDI and the ABM Treaty.

This, then, brings us to the next concern. If you agree that the SDI is in our national interest, how does this relate to the current ABM Treaty? To answer, let us look at some of our basic assumptions in signing the treaty back in 1972. One of the critical assumptions was that both sides would adhere to the strategic theory of mutual assured destruction, that both sides would limit their offensive retaliatory forces to what was needed for a first strike. Another assumption was that we would agree to further formal limits on offensive forces. And finally, the United States assumed that there would, in fact, be compliance with the treaty.

Many of these assumptions have proven to be false. The Soviets may never have believed in mutual assured destruction. The large number of heavy, accurate ICBMs they have acquired hardly connotes that they are thinking only of striking second at soft targets. Nor is the United States wedded to mutual assured destruction. As a matter of fact, our Presidential Directive 59, the 1980 Carter Administration strategic doctrine calling for more selective and precise use of nuclear weapons, clearly moves U.S. strategic doctrine *away* from mutual assured destruction. Nor have we been terribly successful in limiting offensive capabilities. In fact, since 1972 we have seen a massive buildup of Soviet offensive warheads that the President's START (Strategic Arms Reduction Talks) proposal, which I support, is trying to reduce to a level of 5,000 warheads on both sides.

Finally, we must review the issue of compliance and the future of the ABM Treaty. There is absolutely no doubt that the Krasnoyarsk radar is a clear-cut violation of the ABM Treaty, yet many people say that the United States needs to continue to adhere to the ABM Treaty. Allowing that it might be counterproductive for the short-term U.S. agenda to drop the treaty, there is the question of

review, which this administration will be very interested in, when the treaty comes up for review in 1987.

The Reagan Administration has, in fact, changed the legal interpretation of the ABM Treaty by changing the interpretation of Agreed Statement D (a statement added to the treaty which stated that "ABM systems based on other physical principles...would be subject to discussion"). The secretaries of state and defense and the other principals involved in the National Security Council all agree to the new legal interpretation of the ABM Treaty. But a new policy will not go forward because the secretary of state has announced that the administration will follow a more restrictive policy than the treaty requires. So far, this restrictive policy has not been defined. Will it mean that the United States will have to change existing SDI contracts or scrap some of its plans? I do not know. I'm going to be asking those questions myself.

How is the ABM Treaty to be interpreted?

Will the SDI be restricted beyond the legal interpretation of the ABM Treaty? At first blush you may say yes, but I'm not so certain. In the President's most recent statement concerning what SDI the United States should pursue, he mentioned research, testing, and development. He said those words very clearly. He may feel that the United States can, in fact, begin to test SDI systems, even though the restrictive policy says "just research." What "just research" is will have to be carefully defined. I think we ought to have a very serious discussion of the ABM Treaty and its relationship to SDI.

My final point is that the United States ought at least to adhere to the same interpretation of the ABM Treaty as the Soviets. That would certainly allow for the development of an ATBM system in Europe. The Soviets have their own ATBM system, and there's no reason why we and our allies should not have an ATBM system. There's a lot that we can learn technically by moving ahead with deployment of an ATBM system in Europe compatible with the ABM Treaty.

THIRD SPEAKER: JAMES H. HOLMES *(Director of the Office of Strategic Nuclear Policy of the Bureau for Political and Military Affairs, Department of State)*

U.S. position on on ABM Treaty interpretation.

I don't want to repeat comments made earlier, but I do want to respond to the points raised by a previous speaker as to precisely where the administration is on the question of the SDI research program, the applicability of the ABM Treaty, and how it's interpreted. I thought that it might be useful if I provided a statement of the administration's policy in this respect. I would note that the secretary of state's October 1985 speech before NATO lawmakers in San Francisco captured the essence of the policy.

The U.S. research program is and will continue to be consistent with the ABM Treaty. The treaty can be, indeed it has been, variously interpreted as to what kinds of development and testing are permitted, particularly with respect to future systems and components based on "other physical principles." The treaty's text, the agreed statements accompanying it, the negotiating records, and official statements made since the time of the negotiation are all subject to different interpretations.

A broader interpretation justified but beside the point.

Because of the great potential contribution that strategic defense could make to our security, and because of our interest in a rigorous implementation of the ABM Treaty by both sides, we in the administration have devoted much attention to the question of how to interpret the treaty. It's the administration's view, based on a careful analysis of the treaty text and the negotiating record, that a broader interpretation of our authority to develop and test ABM systems and components based on "other physical principles" is fully justified. This broader interpretation is, however, beside the point, since the U.S. SDI research program has been structured and will continue to be conducted in full accordance with a restrictive interpretation of the treaty's obligations. That is as the President directed.

James Holmes spoke later in the program but his statement has been placed here for presentational purposes.

The SDI Report to Congress issued in March 1985 also affirms that the SDI program will be conducted in a fully compliant manner to reach a decision point in the early 1990s on whether to proceed to development and deployment of an SDI-related system. At that time, based upon the conditions that we and our allies face and the behavior of the Soviet Union in the interim, the United States will have the opportunity to reassess the guidance that the President has set forth.

Furthermore, any deployment decision would be the subject of consultations with our allies—consultations which are already ongoing in the manner of normal consultations with the allies on the SDI, though not yet with respect to deployment—and would be a matter of discussion and negotiation with the Soviets as appropriate and in accordance with the terms of the ABM Treaty.

Discussion

QUESTION:

A previous speaker said he found it ludicrous that the United States took the more restrictive ABM Treaty interpretation for itself but said that the less restrictive one was also valid, therefore leaving that one open to the Soviets. How would you respond to his criticism?

HOLMES:

Broad versus narrow interpretations of the treaty.

The administration has carefully reviewed the text of the treaty and the record of negotiations and has found that in 1971-72, during the time that the treaty was being negotiated, the Soviets did not agree to our insistence that future systems based on "other physical principles" be banned. As we went through the treaty it became clear that the statements which the United States has offered unilaterally over the last twelve years with respect to the treaty tended to obligate ourselves but without any reciprocity on the part of the Soviets. It became clear to us that the Soviets do not feel similarly bound, that there was ample room within the treaty and the interpretation of the treaty for the United States to regard it in a broader context, a context which

would permit us to do more in the way of development and testing under the SDI research program.

But the key point is that under the SDI research program it is not necessary for the United States to go into this legal interpretation or to argue the questions of broad vs. narrow interpretation because the President's commitment to the Congress, the allies, and the public from the time that we began this research has been that the United States would conduct the SDI research program under the restrictive interpretation of the treaty, and we have designed a research program which fits within the confines of that interpretation. Therefore, the issue of whether or not it's broad or restrictive is not really material to the question of the SDI research program. In the future when the United States is able to answer the basic technological feasibility questions and when a future President and a future Congress are asked to make decisions with respect to development, testing, and deployment, then the matter of interpretation may come into play. But it's not a question which we need to address for the life of the research program.

Decisions on testing and deployment are for a future Congress and President.

QUESTION:

It's clear that a long-term effort will be needed to sustain the SDI and that Senate support will be needed throughout if that SDI effort is going to be successful. Senator Quayle, what is your assessment of the nature of Congressional support for SDI? Specifically, the Congress has tended to tie arms procurement to arms control. A good example of this is the 1983 effort, sponsored by Senators Sam Nunn (D-Ga.) and William S. Cohen (R-Me.), to tie the MX missile to the build-down. Do you see that kind of an effort with the SDI in the future?

QUAYLE:

That depends on what kind of political developments arise on Capitol Hill. There's no doubt that the Scowcroft Commission (to study MX basing options) and the connection between arms control and the MX missile were a political device to fund the MX missile. The problem with the MX was that

Congressional views.

there was no clear-cut course on where to base the missile.

If, in fact, the administration does not have a clear-cut course on where to go with the SDI, then, for political reasons the SDI may pass only in exchange for arms control arrangements. I think that the SDI will be very helpful to arms control in the long term, assuming that it works. But the administration is going to have to make sure that its policy is presented in a very cogent, understandable, and predictable manner. As a supporter of the SDI and of this administration, I would say that SDI has not been explained terribly skillfully. If the administration goes back and forth too much on the ABM Treaty interpretation issue, then it runs the risk of having to repeat the MX funding device— it will have to devise some new arms control proposal to get the SDI passed.

Tying arms procurement to arms control.

The administration also runs a risk if it interprets the ABM Treaty so restrictively that the SDI is limited to the laboratories. Then some SDI supporters will say, "Well, fine. We can spend money elsewhere. If we're just simply going to stay within the laboratory, then why are we investing this money in the first place?"

QUESTION:

We have a very complete public record on the legal interpretations of U.S. obligations under the ABM Treaty. Those legal interpretations were presented to the Senate when the SALT I accords were brought before the Congress. Every subsequent administration has given precisely the same legal interpretation of U.S. obligations, including the current administration, until very recently. The Reagan Administration has a very expansive view of the SDI, which can't fit within the old legal interpretation of the ABM Treaty. Aren't you just a little bit suspicious of this new legal interpretation?

QUAYLE:

In the negotiations of 1972 the United States really pushed for an outright ban on ABM systems based on "other physical principles." But the Soviets

rejected such a ban, and Agreed Statement D of the treaty then evolved from that. The secretary of state and the secretary of defense are both in accord that Agreed Statement D of the ABM Treaty does allow for research, testing, and development of ABM systems based on other physical principles. It does not allow for deployment.

Agreed Statement D.

SMITH:

Senator Quayle is correct that during the negotiations the Soviets were much less enthusiastic about controlling what the United States calls "exotic systems," but we finally got the language of Article 5, which says, in effect, "Thou shalt not develop space-based systems." There's no qualification at all. The U.S. Joint Chiefs of Staff were very anxious that the United States preserve the right to develop new types of land-based systems, and therefore the language of Agreed Statement D left that open. It permits research and development of new land-based systems within other existing limitations. The language is not as clear as with hindsight we'd like to have it, but I don't see how any lawyer can say that an agreed statement overrides a flat provision of the treaty.

QUESTION:

European views.

Do you think that there may be a problem from somebody in London or Bonn who sees the United States suddenly reverse its position on a treaty that it upheld for 13 years? Perhaps they may fear that the same thing could happen to the NATO Treaty, for example.

QUAYLE:

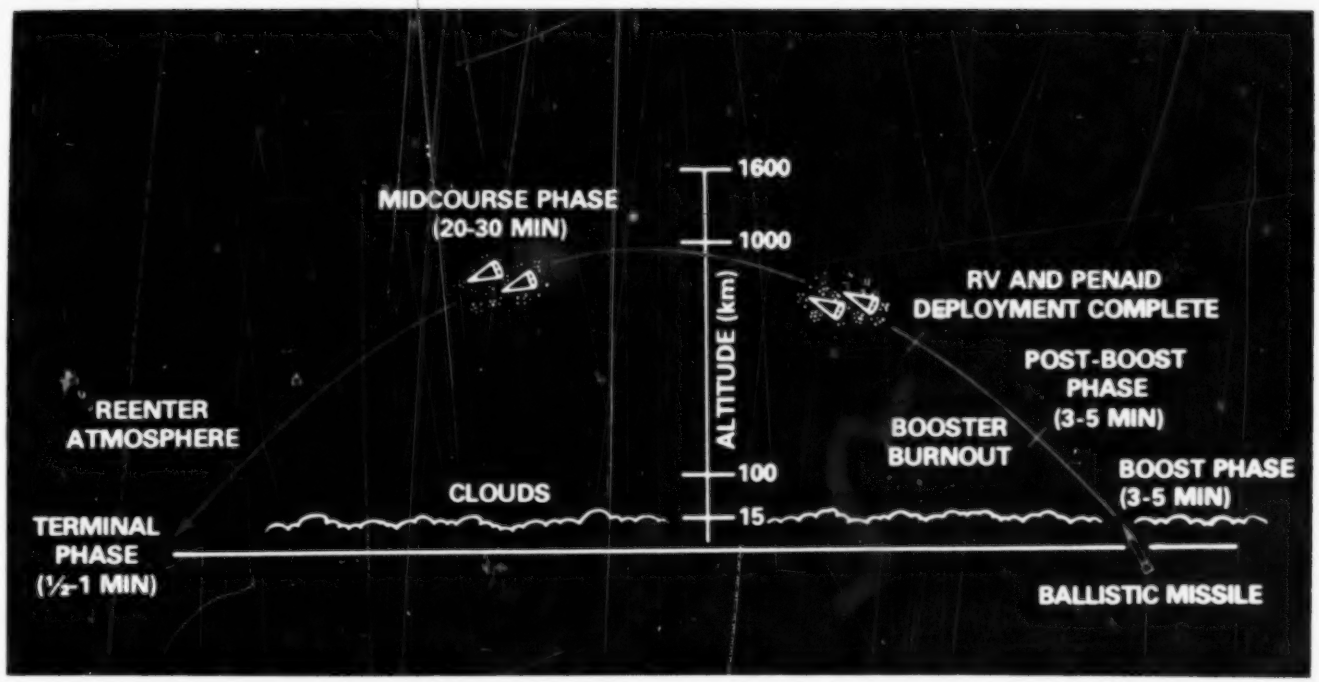
It should not cause any problems with the Western alliance. I think that our Western allies should, in fact, agree to our interpretation of the treaty. They're beginning to come along with support for the SDI much more than they were a year ago. They see the application to their own security in an ATBM system which is related to strategic defenses. I see absolutely no connection at all between our interpretation of the ABM Treaty with the Soviet Union and the NATO Treaty. Our NATO

allies are more concerned about what Congress is going to do in its relationship to NATO, and rightly so.

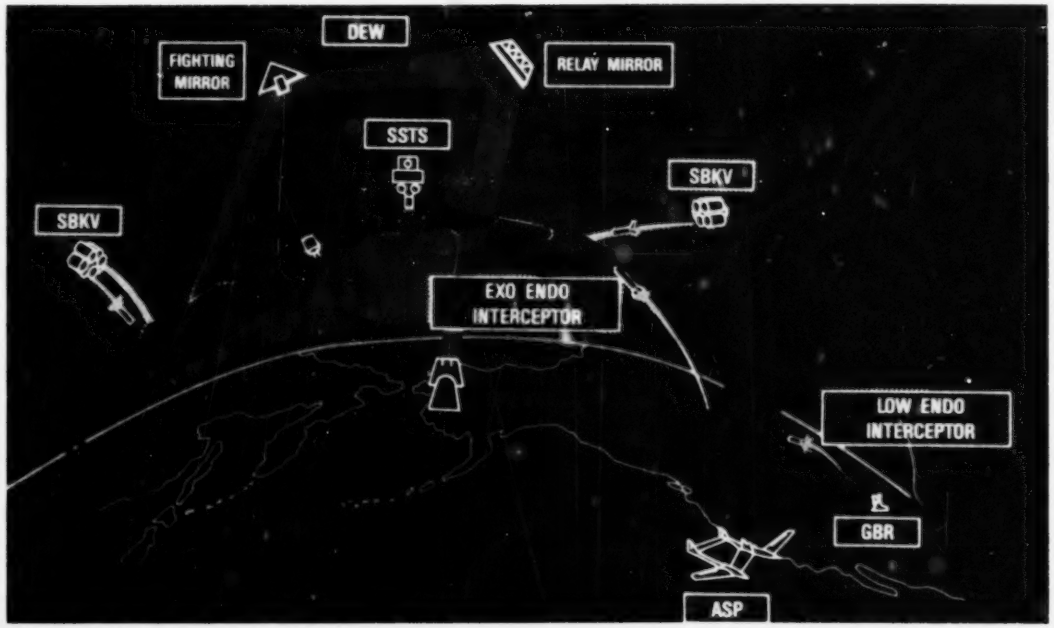
SMITH:

I was struck by the remark attributed to the foreign minister of the Federal Republic of Germany concerning the switch in the ABM Treaty interpretation. He said it's like a carousel, but we don't know who is on the horse.

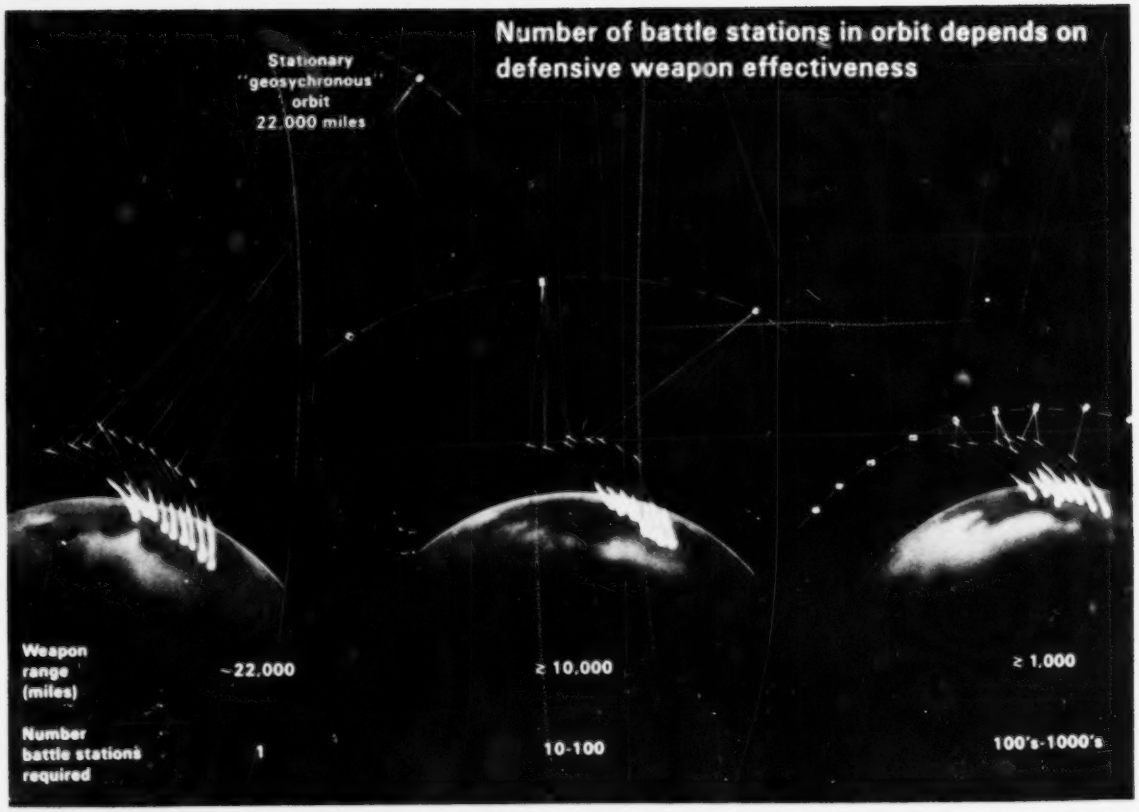
ICBM Flight Phases and SDI Architecture



This chart shows the four basic phases of the flight of an ICBM, (1) the boost phase, when the booster carries the warheads out of the atmosphere, (2) the post-boost phase, when the reentry vehicles and penetration aids are deployed, (3) the long midcourse phase, and (4) the terminal phase, when the reentry vehicles reenter the atmosphere and descend towards their targets.



The architecture of a strategic defense system would provide a layered defense. This drawing shows how various systems might defend against an incoming missile. The space-based sensing and tracking system (SSTS) would monitor the flights of the ICBMs. It would be supplemented by air-borne sensor patrol (ASP) systems. Space-based kinetic kill vehicles (SBKV) would intercept reentry vehicles during the boost and midcourse phases. Directed energy weapons (DEW), in this case a ground-based mirror relayed laser, would intercept reentry vehicles during the post-boost phases. Exo- and endo-atmospheric interceptor missiles would destroy reentry vehicles during the late midcourse and terminal phases of the flight, guided by ground-based radar. Systems architecture will be crucial to the success of SDI.



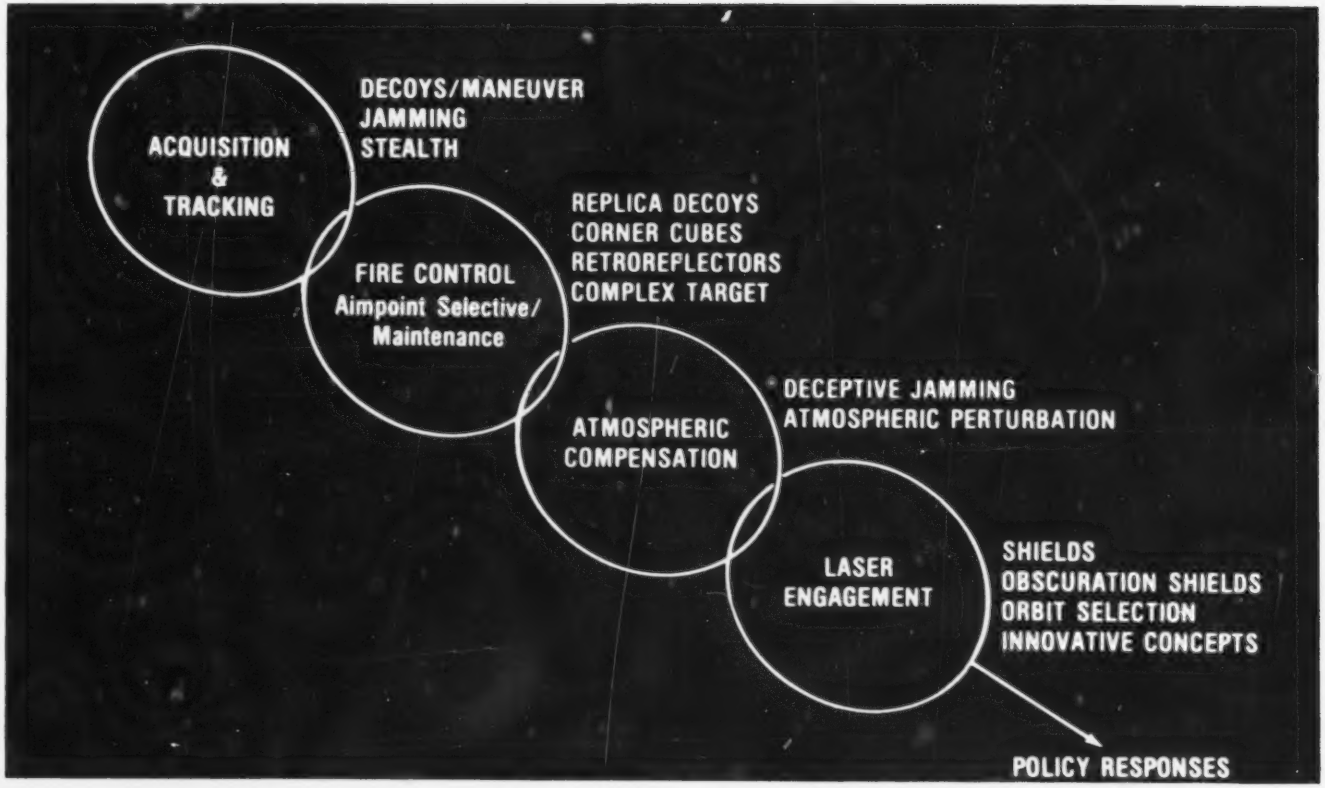
This drawing shows the relationship between the position of a battle station satellite and the number of satellites needed to cover a given number of targets.

Weapon effectiveness (number of kills per battle station) is determined by number of "bullets" per battle station and the speed with which they get to the target
Time-to-target = distance / velocity
Chemical rockets
Parallel kills
Nuclear driven x-ray laser

This drawing shows a kinetic kill vehicle (chemical rocket) and nuclear driven x-ray laser working in parallel. It defines weapons effectiveness for kinetic kill devices.

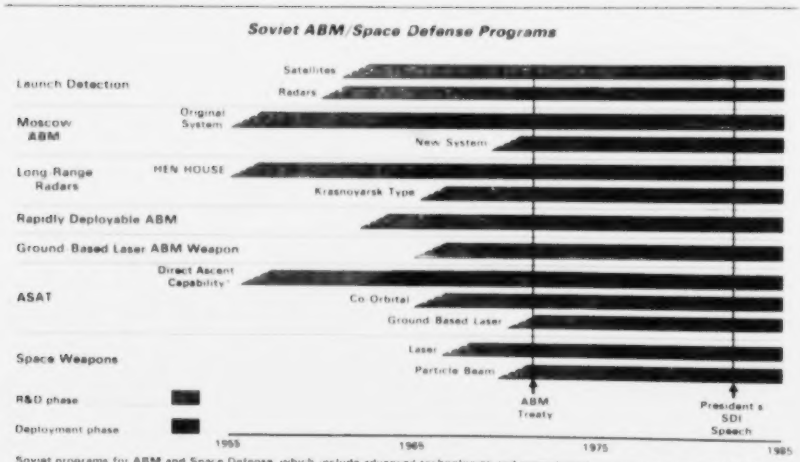
Weapon effectiveness (kill rate) is determined by brightness and retarget time
Sequential kills
Target 3
Range
Retarget time ∝ 1 / Slewing rate
Target 2
Target 1
Brightness determined by laser power and beam divergence
B = P / θ²
• Higher power + narrower beam = longer range, higher kill rate
• Faster retarget time = higher kill rate

This drawing shows that the effectiveness of laser weapons is determined by the brightness of the laser and the retarget time of the system.

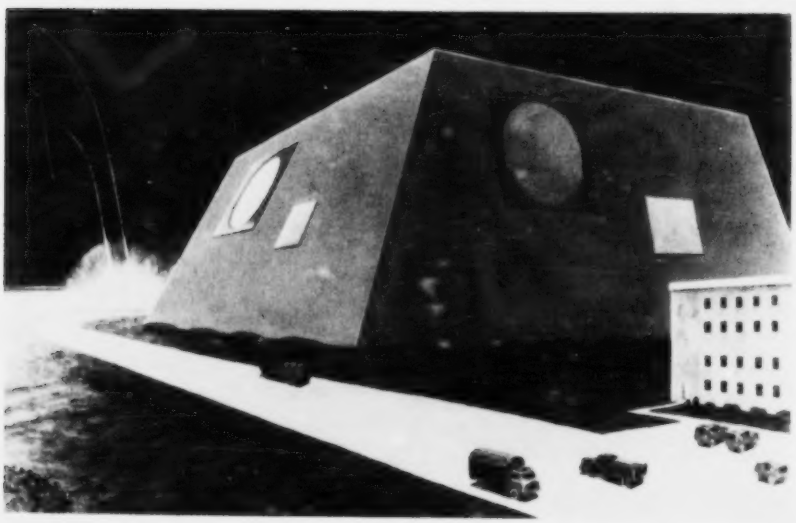


This chart shows potential countermeasures that the Soviets might develop at four different stages of a laser's attack on ICBMs. In addition, the Soviets might use other tactics such as defense suppression, fast burn boosters, and missile proliferation.

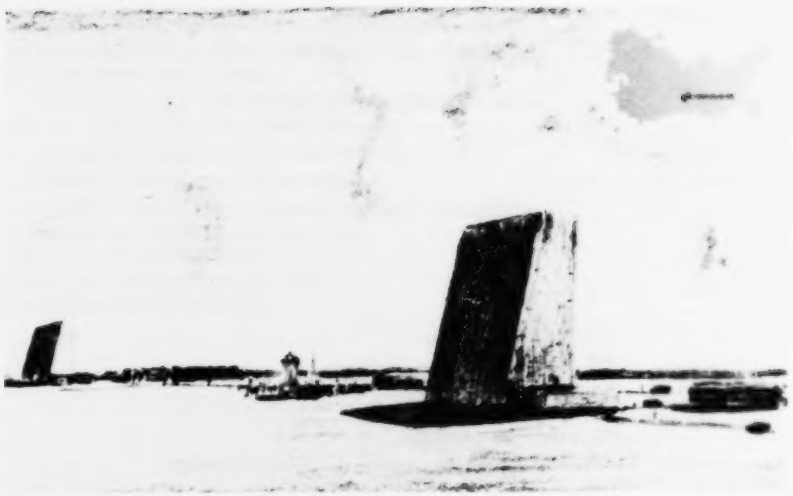
The Soviet ABM/Space Defense Program


Soviet ABM/Space Defense Programs
Launch Detection
Satellites
Radars
Moscow ABM
Original System
New System
Long Range Radars
HEN HOUSE
Krasnoyarsk Type
Rapidly Deployable ABM
Ground Based Laser ABM Weapon
ASAT
Direct Ascent Capability*
Co-Orbital
Ground Based Laser
Space Weapons
Laser
Particle Beam
R&D phase
Deployment phase
ABM Treaty
President s SDI Speech
1955
1965
1975
1985
Soviet programs for ABM and Space Defense, which include advanced technologies and space-based weapons, were in place prior to the 1972 ABM Treaty and have continued to expand in scope and size. During the same time period, US ABM Space Defense research has been limited in scope as well as the level of effort in terms of resources invested.
*Potential capability of the Moscow ABM system

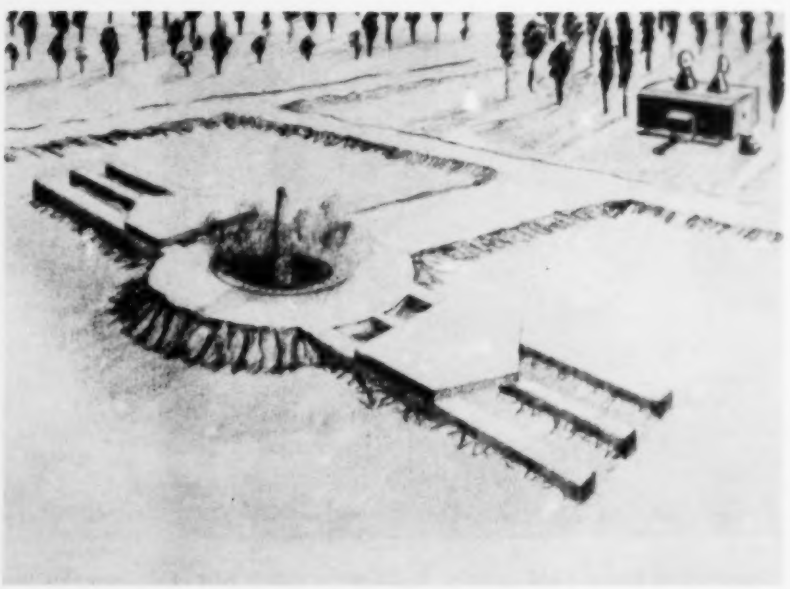
History of Soviet ABM/Space Defense Programs.



Depiction of Soviet ABM radar at Pushkino, which is part of the complex that defends Moscow.

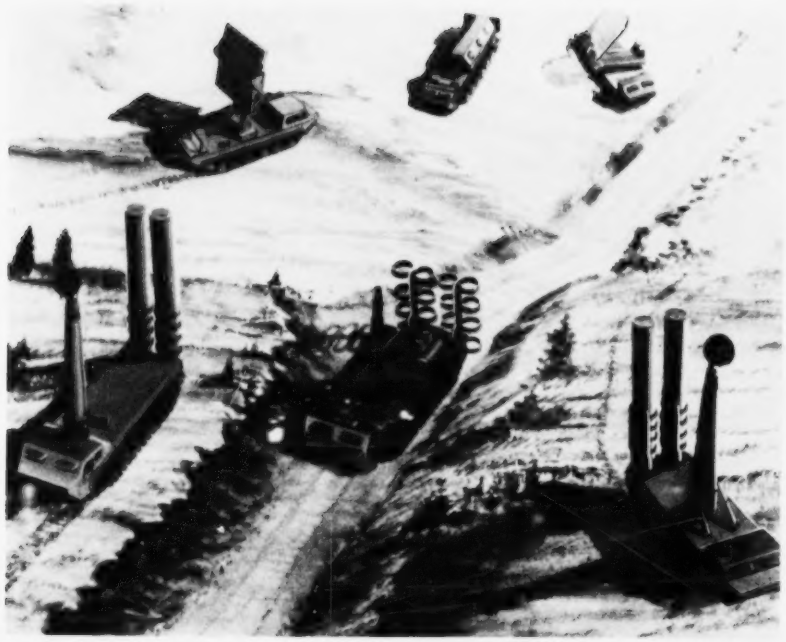


Depiction of the receiver and transmitter at Krasnoyarsk, which is currently under construction. The facility would fill a critical gap in Soviet radar coverage. It is considered by the United States to be in violation of the ABM Treaty.

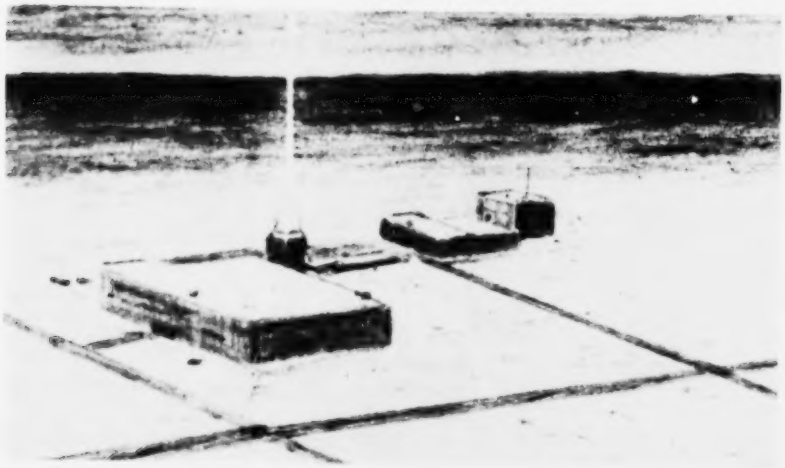


Depiction of a new Soviet silo-based ABM interceptor, which is part of the Soviet effort to modernize Moscow's strategic defenses.

Depiction of a Galosh ABM interceptor, part of the ABM system which currently protects Moscow.

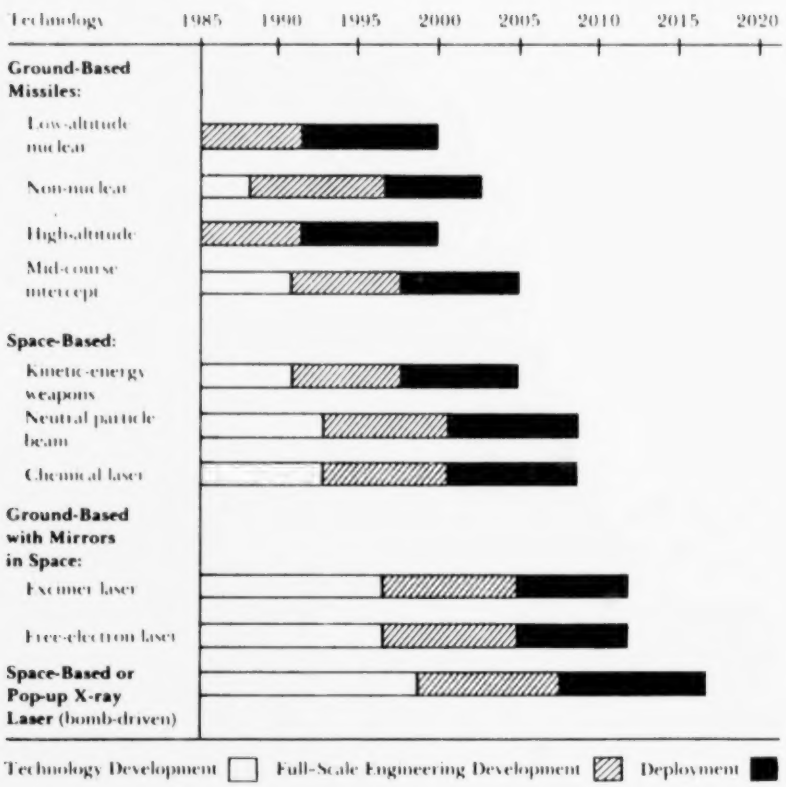


Depiction of the SA-X-12 mobile anti-aircraft and anti-tactical ballistic missile system.

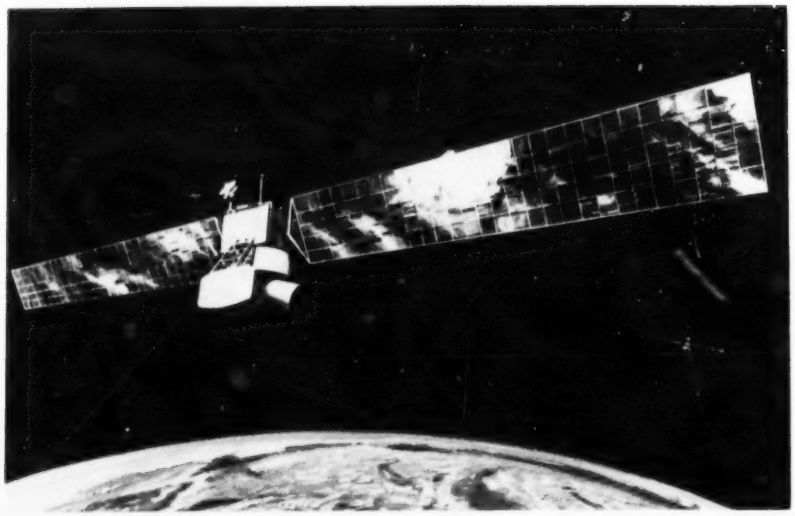


Depiction of a high powered ground-based laser at the Soviet Union's Sary Shagan test range.

Aspects of the U.S. SDI Effort

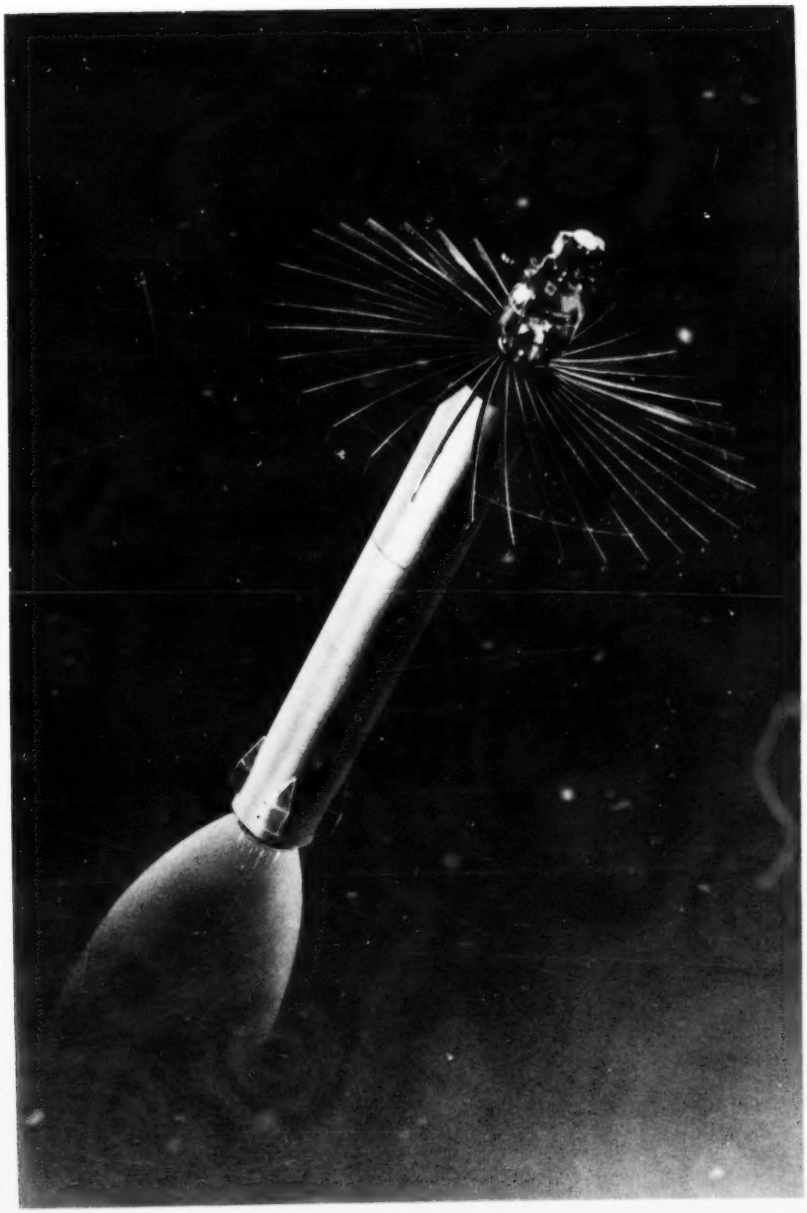


This graph shows the estimated time for development and deployment of SDI technology. (Source: Harold Brown, "Is SDI Technically Feasible?" *Foreign Affairs: America and the World 1985*, page 443.)

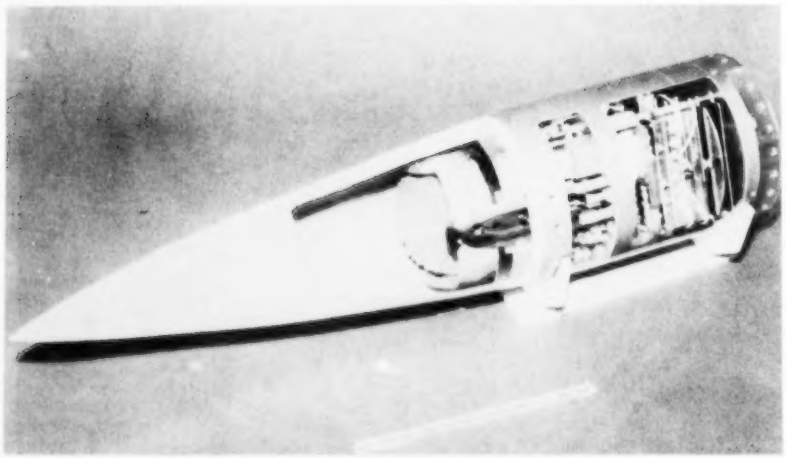


A space-based sensor system placed at high altitudes would allow boost-phase surveillance, while a midcourse surveillance system would enable detection, tracking and discrimination of all objects in low Earth orbit, including warheads, decoys, and debris.

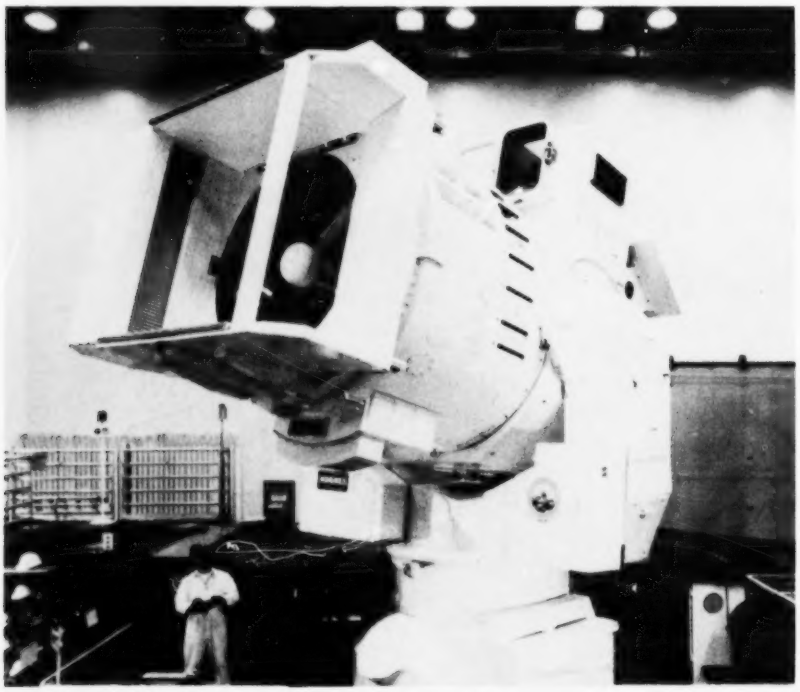
The airborne optical adjunct would optically identify and track warheads at long ranges and then hand over the function to ground-based radar.



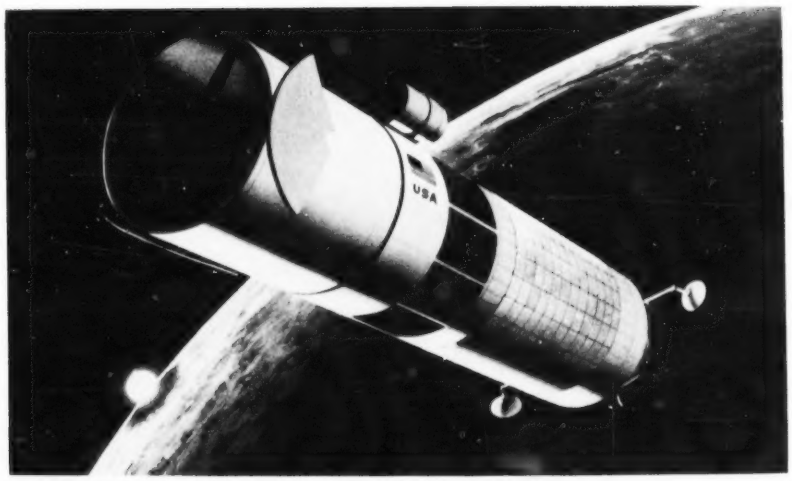
The Homing Overlay Experiment (HOE) non-nuclear interceptor, shown here, is one type of kinetic energy weapon which destroys the reentry vehicle by colliding with it in space. The HOE was successfully tested in June of 1984. The ribbed array is deployed just before impact to maximize the likelihood of a successful intercept.



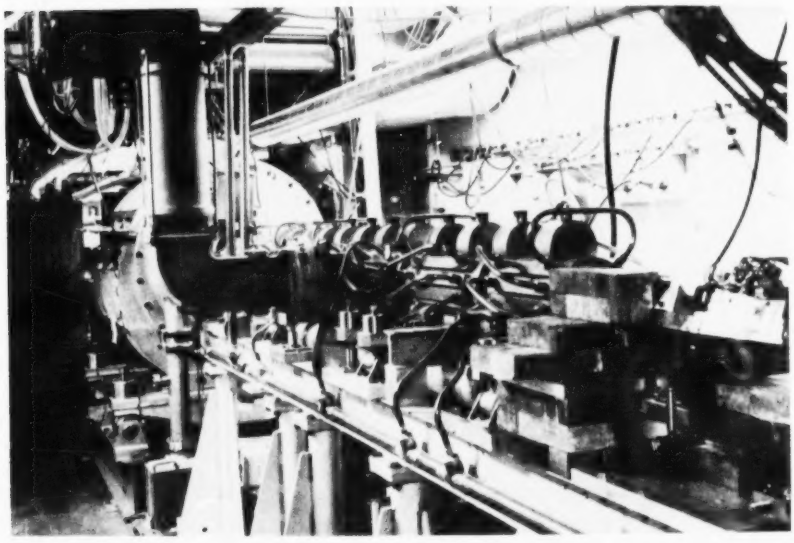
This small radar homing interceptor test vehicle is a kinetic-energy weapon which could be used during the terminal phase of a layered defense.



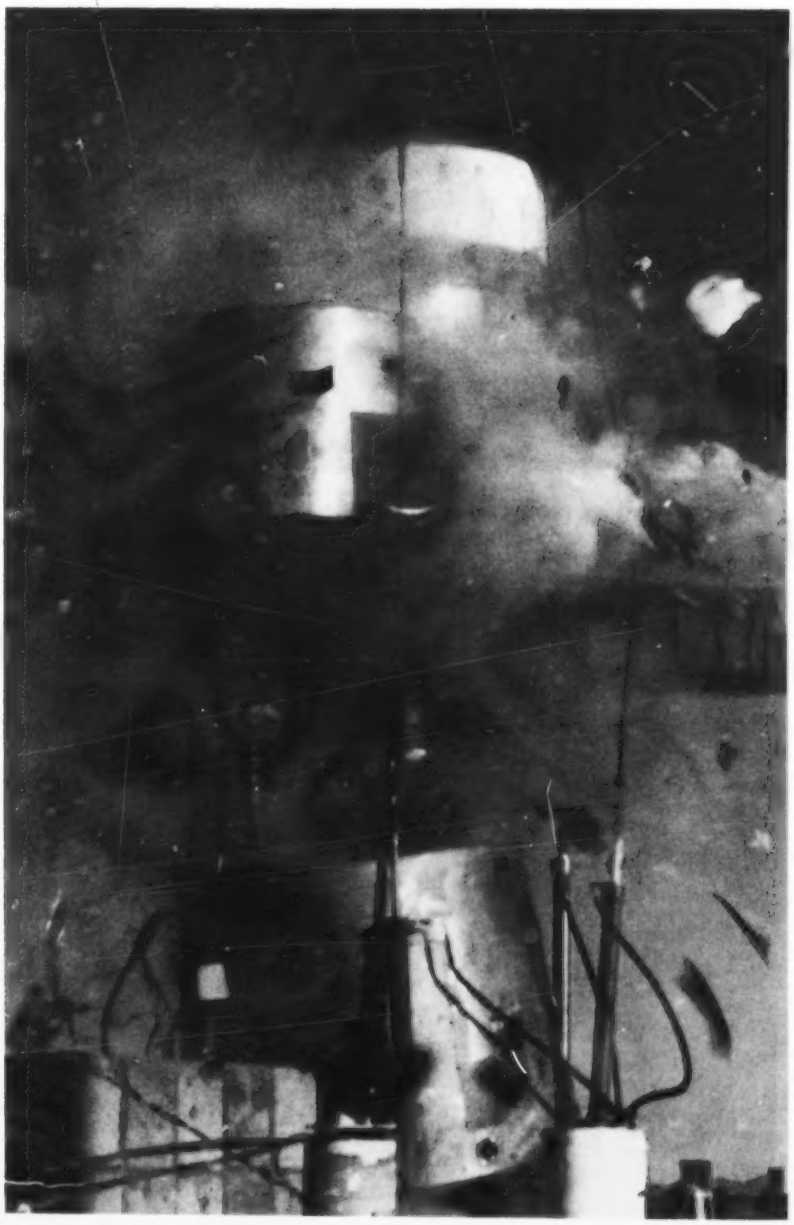
Lasers would be useful in both tracking and destroying incoming reentry vehicles. The Navy's Beam Director is an experimental pointing and tracking system designed to track targets in flight and direct a high powered laser beam to selected aimpoints.



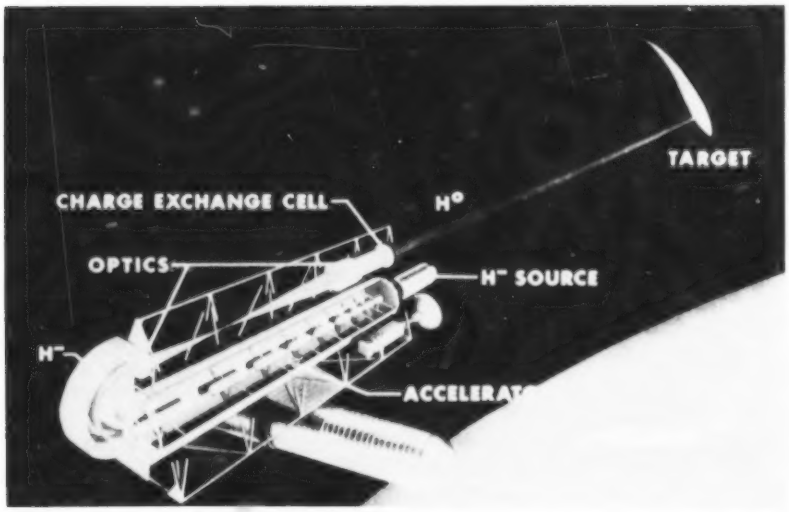
The space-based laser, depicted here, offers an opportunity to intercept ballistic missiles in the boost phase, before they can deploy their warheads and decoys. Since some types of laser light penetrate the atmosphere, this type may also have potential in defense against airbreathing missiles or aircraft.



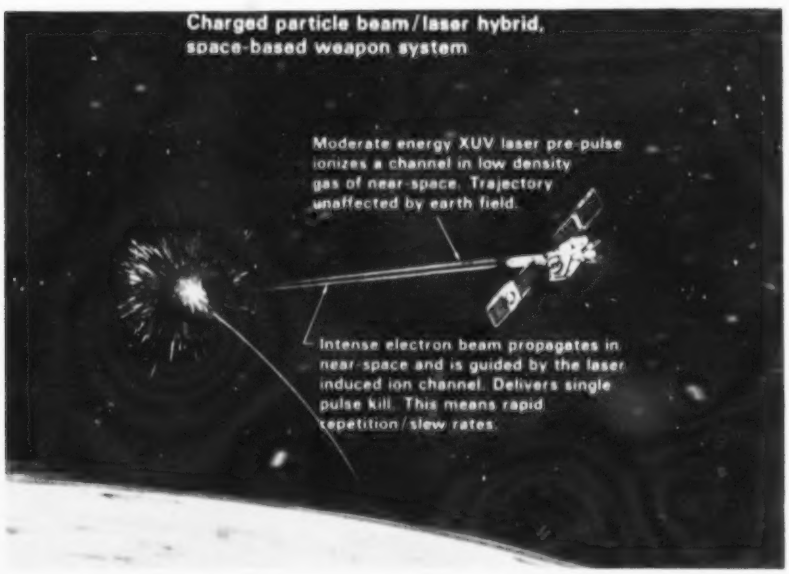
Short-wavelength lasers, such as the free-electron laser (test model shown here) and the excimer, may be feasible for ground-based defense. Recent physics experiments have established the basic feasibility of the free-electron laser, and its operation has been successfully demonstrated at microwave frequencies.



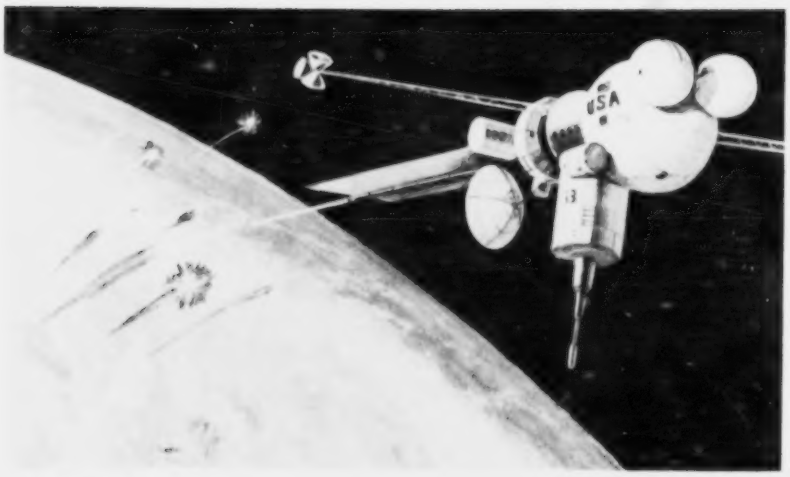
This photo shows the destruction of part of a Titan booster missile by a large chemical laser—the mid-infrared advanced chemical laser. The missile contained no fuel and was irradiated with the high-energy laser beam for several seconds before being destroyed.



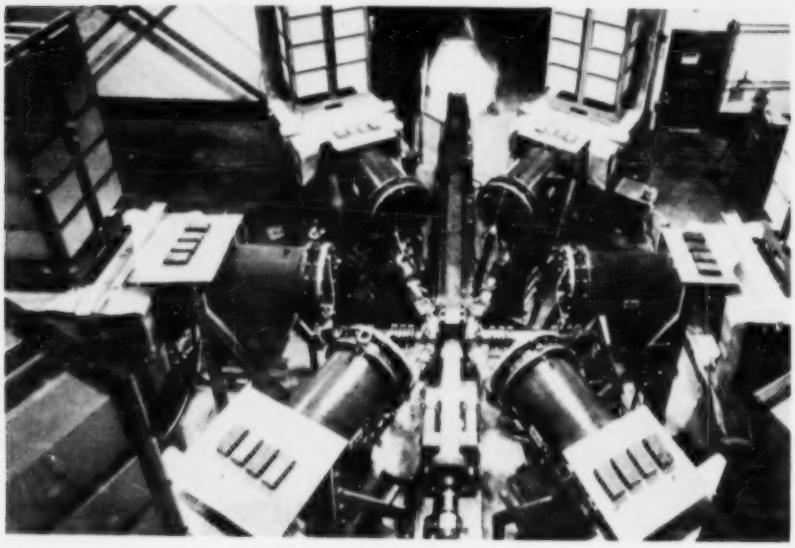
The neutral-particle beam weapon, depicted here, would destroy electronic circuits on ballistic missiles. This system would accelerate atomic particles to high speeds, point them using magnets, and then neutralize their charge so they are not affected by the Earth's magnetic field.


Charged particle beam/laser hybrid, space-based weapon system
Moderate energy XUV laser pre-pulse ionizes a channel in low density gas of near-space. Trajectory unaffected by earth field.
Intense electron beam propagates in near-space and is guided by the laser induced ion channel. Delivers single pulse kill. This means rapid repetition/slew rates.

The laser-guided electron beam combines laser and particle beam technology. This concept, called "Antigone," would fire a laser ahead of a particle beam, thus creating a passage free of magnetic field which could deflect the beam.



The electromagnetic launcher (EML) or railgun depicted here would accelerate small projectiles to ultra-high velocities using electric and magnetic energy. Projectile speeds would be more than three times that of chemical rockets. Railguns could be used in all phases of ballistic missile flight.



This photo shows a test model of the railgun at Maxwell Laboratories in California. A 0.3 pound plastic shell, fired at a velocity of about three kilometers per second, completely penetrated a one-inch thick steel plate.

Session V
The SDI and Strategic Doctrine

FIRST SPEAKER: LEON SLOSS *(President, Leon Sloss Associates)*

The common perception is that the SDI represents a major revolution in strategy. I will propound a contrary thesis that the SDI is not as revolutionary as most people think. It can be seen as a logical evolutionary step in the development of U.S. nuclear strategy. In order to support that thesis, I will give you my definition of the SDI, summarize how U.S. strategy has evolved, and then show how this is a continuation of a trend.

The SDI is evolutionary, not revolutionary.

What is the SDI? At the moment the SDI is a research program and nothing more. Its purpose is to determine what may be feasible and also how what may be feasible will affect U.S. security. The current debate on the SDI is really about what it might become, not what it is. There are three broad possibilities. First, it may become an impossible dream. We may well find that, as we study these technologies, they won't be able to do what the enthusiasts think they'll do. I'm somewhat more optimistic than that, however. Second, it may become a means of making nuclear weapons impotent and obsolete. The President established that as the goal of the SDI in his famous March 23, 1983, speech. I'm somewhat skeptical about that, but at least that's a possibility. Or third, the SDI may be a way to strengthen deterrence in combination with and not as a substitute for strategic offensive forces.

What the SDI may become.

The latter two possibilities, that is, a near-perfect defense or an intermediate defense, are not incompatible. It is quite possible to see a progression of events over several decades in which the United States moves toward increasingly competent defenses. In fact it's hard to see how we can move to near-perfect strategic defenses right away. If we decide to go ahead with the deployment of strategic defenses, for quite some time those defenses will be far less than perfect and substantial offensive forces will be around.

Factors that have driven changes in nuclear strategy.

Four major factors have driven an evolution in nuclear strategy from 1950 to the present. The first is changes in the threat to which we have had to respond. The net effect of those changes has been to narrow U.S. options. The second factor is foreign commitments. The commitment to extend nuclear deterrence to our NATO allies has been a major determinant of U.S. strategic doctrine and forces. The third factor is the rapid change in nuclear weapons, missiles, and command, control, and communications technology. And the fourth factor is economics. It's an inescapable fact that nuclear weapons, while dangerous, are relatively cheap, and that has been an important consideration in driving the United States to a strategy which, in my view, is overly dependent on nuclear weapons.

Massive retaliation.

In the 1950s when the United States began to think about how to integrate nuclear weapons into strategic policy, we relied heavily on the threat of U.S. massive retaliation. This worked in an era of massive U.S. nuclear superiority. But it didn't work for very long. The first challenge to massive retaliation came from abroad in the 1950s when French President Charles De Gaulle questioned whether the United States would be prepared to risk New York for Paris.

Assured destruction and damage limitation.

The second phase of nuclear strategy came during the early 1960s when Robert McNamara was secretary of defense. During that period U.S. nuclear strategy was based on two principles: assured destruction and damage limitation. Assured destruction was our ability to retaliate against any kind of attack on the United States. Damage limitation was primarily a counterforce strategy to limit nuclear damage to both sides in time of war. We also had a brief flirtation in the 1960s with ballistic missile defense and counterforce strategies, but the focus was on assured destruction and damage limitation.

By 1967-68, damage limitation had gradually been downgraded and mutual assured destruction was seen as the principal role of strategic forces. In that famous meeting with Soviet Premier Aleksei A. Kosygin in Glassboro, New Jersey, in 1967,

McNamara argued that it would be in our common interest to do away with defenses, which were only destabilizing and would never really work effectively. All through this period, too, McNamara pushed very hard, particularly with our allies, to improve conventional defenses and reduce reliance on nuclear weapons. Unfortunately, in my view, he had little success.

The search for options.

The next phase was the Nixon-Carter-Reagan era in which a great deal of continuity can be seen. This phase was characterized by the search for options. It began with President Nixon's statement in 1970 that called for having options in U.S. strategic plans so no President would be left with the choice between massive retaliation and surrender. That led to a whole series of studies and reevaluations from which the concept of escalation control gradually emerged. We began to see the futility, as the Soviet force proliferated, of an effective counterforce policy. The importance of reserve forces was given greater emphasis. Dual criteria, that is, what to strike and what to avoid in attacks, was given more emphasis. The possibility of prolonged wars was recognized.

Countervailing strategy.

Finally in the late 1970s out of all this emerged the countervailing strategy, as articulated by Secretary of Defense Harold Brown and reflected in Presidential Directive 59. An important focus of that strategy was on shaping the enemy's perceptions. The strategy emphasized counterforce and counter-leadership targeting, not so much as a war-fighting objective, but because the United States recognized that the Soviets had a war-fighting objective. In order to deter the Soviets, we had to have credible capabilities to attack their strategy and to deny them confidence in achieving those objectives. Even as Harold Brown articulated this policy, he expressed his own skepticism about ever being able to use nuclear weapons in a war-fighting role. And yet, because the Soviets appeared to embrace this concept, we had to design our deterrent to counter that. There was no role for defenses in this strategy and there hadn't been since the signing of the ABM Treaty in 1972.

There were problems, however, with the countervailing strategy. It was far more demanding. It required flexibility and endurance in forces. And the Soviets worked very hard to counter the new strategy, particularly through a variety of defensive measures including hardening, mobility, concealment, and active defense. Our European allies were very nervous with the war-fighting aspects of the new strategy, and the United States kept wavering between whether it really was a war-fighting strategy or not.

Nuclear freeze movement.

As the public became engaged in the debate in the late 1970s and early 1980s, there were fears and pressures to reduce reliance on nuclear weapons. The nuclear freeze movement and the 1983 National Conference of Roman Catholic Bishops' letter calling for curbs on the development and production of weapons, entered into the debate. There was even bureaucratic resistance in the military to procuring the capabilities necessary to implement such a strategy, particularly command, control, and intelligence capabilities, which turned out to be very expensive.

This leads logically to President Reagan's March 1983 SDI speech, which it seems to me reflects three themes that I've tried to develop. First, it clearly was a response to public concerns, the moral concerns that were expressed in the freeze movement and the Catholic Bishops' letter. It was a message of hope that perhaps there was a chance of doing away with this threat of nuclear weapons that hung over us all. Second, it was also a response to strategic concerns. It became clear to many in the Pentagon that even a massive strategic modernization effort was unlikely to close the strategy capability gap with the Soviets. The Soviets were also quickly producing offensive systems and a massive investment in offensive forces was at best likely to leave us in about the same position as we had been before. Third, the SDI speech was seen in part as a new approach to arms control. Paul Nitze and others argued that growing defenses would help to persuade the Soviets of the logic of offensive reductions.

Concerns about the SDI.

But SDI clearly has its problems. The message has been confused for many months, particularly the relationship between the long-term objective of a population defense and the intermediate objective which has been incorrectly described as a defense of missiles. The scientific community has been highly skeptical about the prospects of achieving a "defense," and part of that skepticism is because of the administration's lack of clarity. Often the debate takes place in a total vacuum with no one defining which "defense" is meant. The arms control community has also been aroused about the threat to the ABM Treaty, and the allies have been very uneasy for a number of reasons, including their concern about any change in nuclear strategy and the effect of the SDI on NATO strategy.

Limited choices.

My principal conclusion is that the choice is not between having no defense and having a perfect defense. In fact, neither of these are real choices in the short run. Defense is here. The Soviets are well beyond zero strategic defense now, if defense is defined in the broad sense. Even if the definition is narrowed to ballistic missile defense, they have some deployments and a substantial production base. Furthermore, there is a growing ambiguity between air defense and ballistic missile defense; advanced Soviet air defenses have some capability against ballistic missiles. The United States could choose to have zero defense, but then we have to ask what our strategic position is if we have zero and the Soviets have some. On the other hand, a perfect defense, even if it is achievable, is certainly decades in the future. It seems to me that the issue now is what mix of offense and defense will provide the best deterrent and the best hedge against failure of deterrence.

Defenses, even if modest, can contribute to deterrence by denying an adversary confidence of success in achieving his military objectives. And in that sense the SDI seems to me quite consistent with the goal of the countervailing strategy as it was articulated in the Carter Administration. That's where I see the continuity.

The question of stability.

A key issue is whether we can introduce defenses in a way that will add to stability rather than reduce it. There are many uncertainties about this, but I don't think it's evident that defenses need be destabilizing. Defense and offense are abstract concepts. One must specify what kind of defense and offense is being sought in order to talk sensibly about stability. In any event, it seems to me we had better learn how to live in a world with strategic defenses because that world is here now.

SECOND SPEAKER: WALTER SLOCOMBE *(Attorney with the firm Caplin and Drysdale and Adjunct Fellow, Georgetown University Center for Strategic and International Studies)*

The SDI is here to stay.

Strategic defense is here to stay. The reelected Reagan Administration is committed to this program. Certainty of survival does not mean unanimity on purpose. The SDI is described variously as a plan to eliminate nuclear weapons and to replace assured destruction with assured survival, as a method of keeping Silicon Valley in BMWs for the indefinite future, as a device primarily to trump the freeze movement's ace, or as a negotiating tactic. But it is here to stay.

The SDI challenges the current strategic framework.

Whether or not missile defense technology will produce results which turn out to be strategically and economically worth deploying is, to put it mildly, debatable. But now, with the technology by which to implement this strategic revolution far from being developed, the West is already beginning to feel the familiar, if far from comfortable, ground on which it has built its security trembling beneath its feet. The quest for this shifting grail of strategic defense poses a challenge to the strategic framework within which the West has worked out its security arrangements, successfully however imperfectly, in the past.

The emphasis on strategic defense is not a monopoly of the Reagan Administration. There is a serious Soviet program. It's scarcely the fearsome force that is sometimes described, but it is an across-the-board and vigorous effort. The problem for Western strategy is to find a way to deal with

the SDI program that recognizes that it will neither go away quickly nor attain instant or indeed early success.

The real objective of the SDI.

We really do need to be somewhat more honest and direct about the objectives of the SDI. So far as I know, none of the technical work holds out as a serious objective the idea of protecting the population of the United States or our allies against a determined attack. That is an unpleasant fact which, understandably, is not very widely circulated by proponents of the program, but it is a fact. The SDI is in reality a program to develop various kinds of limited defenses. There is never going to be an alternative to deterrence.

The formula which a lot of people—most Western European governments, the bulk of the Congress, and many people like myself who are skeptics about even the technical prospects—have come up with for the SDI is that they're in favor of research. It's very hard in a technological world to be against research if you think you are going to get a chance to get a piece of the action. Dizzy with success from the conventional arms two-way street, the administration is seducing quite willing European contractors with the idea that the SDI is a pot of gold at the end of the rainbow.

Political and strategic judgments.

However, there is in fact a great deal to be learned from an honest research program. But a good deal more is required than technically honest work. There is a succession of political and strategic judgments that have to be faced. The United States must not first carry out research to establish that a weapon is deployable, and then invent a rationale for deploying it. Instead, we need to ask now why it is we want to develop strategic defense weaponry and to set criteria in advance to determine whether what is technologically feasible is in our interest.

In this connection, a number of considerations can already be identified. First, the protection of silos and of critical military targets, whether here or in Europe, is a perfectly legitimate military mission which may well be served by ballistic missile defense. But ballistic missile defense is not the only way to achieve those objectives. There are other

The protection of military targets.

means to such ends. For example, there is an exciting new development in the area of making ICBMs survivable in which the missiles are moved around. (This sounds vaguely familiar to us former backers of the racetrack system.) There are alternative ways to achieve all of the limited military functions of the SDI.

Opportunity costs.

Second, there are important opportunity costs which rise to the level of strategic choices for the United States as well as for Western Europe. Because of the overwhelming deficit problem in the United States, we face the near-certain prospect that, over the next four or five years, we will do very well simply to keep the defense budget from declining in real terms. That means that money spent on ballistic missile defense work is not new money but money not spent on something else. If all that can be advertised for SDI concepts is that they will complicate, but not block, particular types of attack, we must consider whether the same amount of money spent, for example, on improved communications, on better mobility, or on more technologically modern and combat-worthy conventional forces would produce a greater contribution to Western military security.

NATO solidarity.

Third, there are political costs. There are some serious costs in terms of alliance solidarity. Alliance solidarity should never be an excuse for the United States not to do things which are wise and right, but we do need to pay attention to the very considerable concerns of many allied countries.

The Soviet reaction.

Fourth, we have to think about the Soviet reaction. The Soviets will always act in their own interest. However, if the United States faced the kind of strategic initiative on the part of the Soviets which we are posing to them, our reaction would hardly be to cut back substantially on our plans to modernize and improve our own forces.

Fifth, we must consider the impact of the SDI on stability in time of crisis. I think it is certain that SDI research will prove that complex strategic defense systems work better before you shoot nuclear weapons at them. That fact will inevitably increase the pressures for a preemptive attack in the

kind of grave crisis which poses the only real possibility that nuclear weapons would be used.

Stability in time of crisis.

Sixth, NATO's doctrine of conventional defense faces serious problems in a world in which both sides have limited ballistic missile defense. There's no question that it would be good for the West to have a strategic defense if it were a unilateral advantage. But the question we need to ask ourselves is whether it would be in the interest of the West if both sides had limited military defenses. For Britain and France, the answer is pretty self-evident. But even for the alliance as a whole, it is important to recognize that it is not the Warsaw Pact, but the NATO alliance, that makes a central part of its overall doctrine of flexible response the ability to mount controlled and selective nuclear attacks on the other side's military facilities. This doctrine is controversial, but it is at the core of flexible response. It seems to me that it is at least open to question as to whether it is in the alliance's interest to foster an arrangement in which only quite large nuclear attacks have a reasonable prospect of reaching specific military targets.

The effect on NATO's doctrine of flexible response.

The final point is that strategically the United States must continue to rely on deterrence, and politically it is a good idea to be honest about that. One of the remarkable things about the SDI debate is that it is no longer the political left which has a monopoly on the argument that deterrence is immoral. Indeed, it is amusing to see some of the new friends that the President has won for deterrence by his support of missile defense as a way to abolish it. The image purveyed by some who seek to fit the square peg of arms control into the round hole of the SDI—attempting to guarantee the agreed elimination of nuclear weapons by limited strategic defenses—reminds me of nothing so much as the Soviet theory of the withering away of the state. This theory is used to justify immense concentrations of centralized power. Paradoxically, the threat of all-out retaliation against the full range of industrial and military targets in this society would, with the kind of defenses which it is realistic to expect, probably remain about as terrible and about as

Deterrence is here to stay.

credible as it is today. What would be made more problematic is deterrence by the threat to use nuclear forces in a limited and focused way against critical military targets. Mutual assured destruction as a fact of life, not a policy, would survive, whatever else changed.

Discussion

QUESTION:

Edward Teller and Carl Sagan probably could agree on one point, that mutual assured destruction is immoral. They're both seeking a different "holy grail" and Walt Slocombe tells us that there isn't one. Mr. Sloss, do you think that there is a holy grail out there, or are we doomed to live with mutual assured destruction as a reality?

SLOSS:

It's more complex than that. If the holy grail is the ability through technology to deny either the United States or the Soviet Union the capacity to destroy cities, I don't think there is a holy grail. Defenses are probably never going to be that good technically. Cities will always be at risk and if you want to view it that way, the ability to destroy the enemy's cities will always be the ultimate deterrent.

Punitive deterrence and denial deterrence.

So I agree we will always have to rely on deterrence. But I think there is an overwhelming tendency among U.S. and Western strategists to equate deterrence with retaliation. That is a mistake. For years we've talked about a punitive deterrent and a denial deterrent. That is, there are two ways to deter an adversary. One is by the threat of punishment; the other is by the threat of denying his objectives. The latter has been discussed in many theoretical papers but has never had much influence on the actual development of U.S. strategy. If defense is going to play any role in our strategy in the next 15, 20, probably 30 years, it's going to be in creating a better denial form of deterrence so that it becomes more difficult, more costly, and more complicated for the Soviets to calculate a successful outcome from a first strike. That doesn't mean that the retaliatory threat is going to go away.

It's going to be there too, and defenses may serve to add something to it.

Strategic defense options.

I think that a mistake is made when analysts say there are two options for strategic defense. One is to defend silos so we can continue to maintain a retaliatory capability. The other is to defend populations so that we can get rid of the missiles and the bombers. There's a very large scope for defenses between those extremes. We can see, for example, how Soviet defenses have impacted upon the U.S. deterrent. The Soviets haven't taken away our deterrent capability, but the Soviet air defense system has forced us to rebuild the entire B-52 force, to build the B-1 bomber, and to begin work on the stealth bomber at a cost of billions of dollars. With all of that and in spite of SAC's bravado, there are at least considerable uncertainties about our ability to penetrate Soviet air space. Would it not be to our advantage if the Soviets also had to face such defenses?

QUESTION

A second important pillar of our strategic doctrine, other than mutual assured destruction, has been extended deterrence through flexible response in Europe. Walt Slocombe feels that the SDI will have a negative effect on flexible response. Let me ask Leon Sloss to comment on the impact of the SDI on flexible response.

SLOSS:

A major potential liability of strategic defense is that even modest defenses are going to take away limited nuclear options that are fundamental to current NATO strategy. These limited options have been an important element in extending deterrence to allies, and limited defenses are going to have an impact on that. But it's not the U.S. defenses that will have that impact. It's the Soviet defenses. And only if you believe that our restraint will impose restraint on the Soviets can you point the finger at the U.S. SDI program. The impact of the Soviet defenses on our limited options has been taking place for some period of time, but it was only when the big debate about the U.S. SDI program began in

The impact of the SDI on NATO strategy.

1983 that public attention eventually focused on the Soviet program. The SDI will have an impact on NATO strategy, but it's the Soviet not the U.S. program that the British, the French, and other Europeans are going to have to worry about. I don't think the British and the French are planning to attack us.

SLOCOMBE:

Of course I agree. If the Soviets feel that it is overwhelmingly in their interest to deploy limited strategic defenses, they will go ahead and do so. But I don't think that really is the answer. It is the position of the U.S. administration to encourage the development of a world in which both the United States and the Soviet Union have limited defenses. Indeed, at one point President Reagan stated that we should give the Russians the technology to assure that result. So far any Soviet violations of the ABM Treaty fall very short of giving the Soviets anything like a capacity to deny the NATO option of launching very effective, highly precise nuclear attacks. But implementation of this administration's SDI policy might indeed deny NATO that option.

It is hard to see how Soviet strategy is fundamentally impacted by an inability to carry out limited nuclear strikes against key military targets, whereas it is quite straightforward to see ways in which American and alliance strategy is negatively impacted by not being able to do that. So the United States is pursuing an objective which is simply not in our interest to pursue, at least in terms of NATO's established doctrine. We may have no choice. I agree that if the Soviets develop significant strategic defenses, we are almost certainly better off with defenses of our own. But the current arrangement of fairly severe restrictions on defenses seems to me to be the best combination of all from our point of view and therefore something which is in our interest to preserve if we can.

Air defenses.

The discussion of Soviet air defenses raises an interesting issue. The Russians have spent hundreds of billions of dollars on an air defense system, but I don't think it's fair to dismiss as mere bravado

SAC's judgment that the bombers will get through. In the first place the bombers will get there ten hours after the missiles have hit and so Soviet air defense won't be working very well. Even if that weren't the case, the United States has been able, I believe, even with the B-52s—much less with cruise missiles, stealth bombers, and B1-Bs—to maintain the view that the bombers are capable of carrying out their part of our strategic missions.

Finally, it is instructive to study the experience of the American reaction to Soviet air defenses as an instance of how people behave in the face of limited defenses. It is true that air defenses against SAC is a cost-imposing strategy, but it's not at all clear who the cost has been imposed on.

QUESTION:

There seems to be a difference between the role of strategic defense in U.S. strategy, as you've described it here, and the administration's initial position at the November 1985 summit meeting. Could you give some comments on whether there is in fact a difference in how you would see a transition occurring?

SLOCOMBE:

Transition strategy.

With regard to arms control, I hope the theory of the administration's position is that it is determined to sell high. The less hopeful view is that the administration believes its own theories that the Russians are so scared of the SDI that the United States now has immense leverage or, still worse, that deployment of strategic defenses will be so advantageous to the United States that we should forego the possibility of quite substantial reductions and limitations on offensive forces in the meantime.

The broader issue is the argument that it will be possible for the Russians and the Americans to agree to abolish nuclear weapons and then to use defenses as the way to enforce that agreement. At that point the defenses are unnecessary. If the United States and the Soviet Union are prepared to abolish nuclear weapons at some future time, it is presumably because they have decided they don't pose serious worldwide strategic threats to each

Fundamental changes required in U.S.-U.S.S.R. relationship before nuclear weapons could be abolished.

other. It is hard to see why defenses would be needed to "enforce" such an arrangement. I understand the logic that limited defenses would make it unattractive to have very small nuclear forces, but to get there at all one has to assume that the United States and the Soviet Union have made a fundamental change in their political relationship having nothing to do with technology.

For the short run, which means for three or four decades, the two sides will simply overwhelm the other side's defenses. For a while that is a pretty good strategy. It will even work for the British and French for quite a long time. Thereafter the strategy will be to blow holes in the defenses. A couple of billion-dollar satellites sitting up there in highly predictable orbits will make attractive targets.

Finally, even if missiles can somehow eventually be defeated, that doesn't abolish nuclear weapons. One way the Russians could proceed is by planning to get their bombs in by airplane. As IBM physicist Richard Garwin has observed, if you think getting nuclear weapons into U.S. territory by plane is too hard, try disguising the bombs as bales of marijuana. There are so many ways around the defense that the idea that inventing technologically competent defenses is going to open a way to abolish nuclear weapons by agreement simply has no political reality.

QUESTION:

If the United States develops an effective strategic defense—and presumably because of our computer and software capability we'll be more effective than the Soviets—won't this drive them in other directions where they feel they can penetrate?

SLOCOMBE:

Soviet approaches to technology.

Yes, the Russians are worried about American technology. They rightfully respect our ability to do things in technology, but historically they have not for that reason given up on the effort to maintain military— including nuclear—equivalence with us. As far as the SDI is concerned, they may go around it or under it or try to buy the required technology in southern California. The Soviets will do what is

necessary to penetrate U.S. defenses. The Russians never build weapons which are technologically at the cutting edge but tend to build things which are good enough. Their missions are somewhat different from ours. One of the most important tasks in strategic analysis is to avoid the fallacy that one's own side will have the last move. A lot of pro-SDI arguments depend on our having the last move.

SLOSS:

We Americans tend to seek the ideal solution and need to "plug all the gaps" before we're willing to take the first step. Our technology in the space-based arena probably will stay ahead of the Soviets, but what concerns me, based on past experience, is that we'll have a ten-year debate in the academic community and in Congress about whether we should proceed with the SDI before we have a defense against cruise missiles. Meanwhile, the Soviets will slowly build their system, and in another decade we will find they have a defense that causes us great trouble, and we will have nothing.

QUESTION:

Don't you think history shows that there will be unusual pressures for the deployment of strategic defenses regardless of system validity after a certain amount of money has been invested in their creation? What political controls do you think might be created to guard against this problem?

Economic pressures to deploy strategic defenses: the deficit and the pork barrel.

SLOCOMBE:

There will be an effort to spread the money around to enough places that it's hard to cut back on the program. The effort to do that in Europe is particularly blatant. The B-1 is a classic example of exactly this strategy. On the other hand, money spent on the SDI is going to come out of other defense programs and it's going to come out of things that, from the Armed Service's point of view, really count: aircraft carriers, armored divisions, tactical aircraft, mobility forces. At some point people will ask questions about whether we're really getting anything like a fair trade-off. I'm not

disputing that there may be useful limited defenses, but the economics of the SDI is a contest between the deficit and the pork barrel. There's no very good way around that.

QUESTION:

Stabilizing responses.

The Soviet response to SDI, such as switching to cruise missiles or depressed-trajectory submarine launch missiles, would probably come fairly soon if they thought that the United States was serious about the SDI and was making some progress. Is there any way to channel the Soviet response to weapons that are less destabilizing, say towards cruise missiles as opposed to depressed-trajectory submarine launched missiles?

SLOSS:

First we have to decide what is destabilizing. I'm not at all persuaded by the conventional argument that the cruise missile is less destabilizing than the ballistic missile. The relevant measure is the amount of warning time you have, and cruise missiles take a long time to reach their targets. However, with the prospect of stealthy cruise missiles, the warning time from a cruise missile would likely be near zero. We'd better decide first what's destabilizing, but I'm not terribly optimistic that we can channel Soviet activity, even though it ought to be a consideration in U.S. strategy.

Secretary of Defense McNamara did have some success in this realm in persuading the Soviets to put their missiles in silos. At the time, that was a stabilizing measure. One of the reasons we need to keep the arms control process going is that it offers some potential for dialogue. Just the same, the Soviets are going to design their systems in terms of what they believe their interests are. It's not going to be easy to push them, and it's certainly not going to be easy to push them in ways that they don't want to go.

SLOCOMBE:

We ought not to take at face value the Soviet proposition that until star wars is absolutely, finally, and permanently killed there can't be any limitations on offensive forces. In fact, I think we have

an opportunity in the next few years to work out agreements with the Soviets which they at least purport to be receptive to. Such agreements would both provide for very substantial reductions and limitations on offensive forces and would define what kinds of work on ballistic missile defense is permissible within the framework of the ABM Treaty.

QUESTION:

Should the U.S. continue with SDI without collaboration of NATO allies?

If our allies don't go along with the SDI program, should the United States carry it through alone?

SLOCOMBE:

Sure, we should. If it's really in our interest, the allies shouldn't have a veto over it. But we ought to pay very considerable attention to the concerns that the allies have. One concern is the continuing viability of the British and French nuclear forces. Another is the vastly exaggerated view that if the United States has some kind of defenses, we will pull inside of our astrodome and ignore the Europeans. (We may do that, but not because we have defenses.) Europeans are also concerned that strategic defenses mean a denuclearization of the American commitment, and that has very profound implications for them. Finally, Europeans take the political significance of the arms control process very seriously and see serious political impacts if it were to collapse. In considering whether we will really be serving our long-term strategic and political interests in deploying a ballistic missile defense, we should give due weight to these concerns.

Session VI

Strategic Defense and the European Allies

FIRST SPEAKER: ROBERT HUNTER *(Director of European Studies, Georgetown University Center for Strategic and International Studies)*

The European connection with regard to the SDI or star wars, as it is almost universally called in Western Europe, is the central aspect of the SDI. After all, the SDI doesn't exist, we won't know for years whether it can exist, we don't know how it will affect strategic doctrine, and we're not exactly sure how to handle the SDI issue with the Soviets. But one thing is clear: the SDI is playing a major role in U.S. relations with its Western European allies. And until the issue moves either one way or another, or a way is found to fuzz it quite mightily, it's going to be a preoccupation within the alliance. So even though we're at the tail end of this series of panel discussions, we're now talking about political reality today as opposed to something that might happen after we're all retired.

European connection critical.

Let me start with the good news, since this conference is about the SDI in the twenty-first century. By the twenty-first century a lot of things may well have changed. The nature of the Atlantic alliance or of the U.S. commitment to it may have changed. In fact, the Soviet Union may have changed decisively, either in the nature of its empire or its society, the quality of understandings about European security, or its own commitment to strategic defense. Or our European allies may have learned to live with strategic defenses. The degree of intensity and concern that has been expressed within the Western alliance in the last year on this issue cannot persist for the ten or fifteen years that will be required to make decisions about strategic defenses or to deploy them. The issue will be dealt with in one way or another, and it's partly up to those of us who are professionally engaged in this to see whether it is one way or the other.

The good news.

In fact, certain aspects of strategic defense might even be welcomed by the Europeans. For example, if the United States (notwithstanding the President's view of the SDI) simply went forward with classical ABMs—silo defense, terminal defense, that kind of thing—and if it were done in a rational and a reasonable way over the years, then our allies would have nothing to beef about. Such a development would reinforce the doctrine that applies with NATO today. If the United States' land-based leg of the triad were more secure, theoretically NATO's doctrine of flexible response would be more rather than less credible. If the Administration had simply gone on with some research programs, little would have been said. Unfortunately, President Reagan made a speech on March 23, 1983, and then he created the Strategic Defense Initiative Organization. The Europeans, having gotten through their INF (Intermediate Nuclear Force) debate and having nothing else to worry about, looked around and there was the SDI. The striking thing is that it took about 18 months after the President's speech before this issue became something serious within the alliance.

As someone who on Monday, July 7, 1977, opened his *Washington Post* and read an article by Walter Pincus about the neutron bomb—which I had never heard of even though I was in charge of West European relations at the White House—I can appreciate how these things get out of hand, regardless of their merits.

The bad news.

Now here is the bad news. We have a serious problem in our relations with the NATO allies on the SDI that is not merely a question of more consultations and winning them around to our point of view. I find our European allies almost unanimously opposed to what they believe is the U.S. approach to the SDI. They have some very deep concerns that have not so far been adequately addressed, and quite possibly cannot be addressed if the SDI is pursued as currently planned. For example, the new, broad interpretation of Agreed Statement D of the ABM Treaty struck the allies as ludicrous. Fortunately, the State Department won that battle and the United States is sticking to the correct path.

At the moment, Soviet First Secretary Mikhail Gorbachev is having a field day with us in the competition to win the hearts and minds of Western Europeans. It is probably true that the SDI helped get the Soviets back to the table in Geneva. This has its values politically. But virtually all the activity surrounding the November 1985 summit is about competition in Western Europe, and the centerpiece of that activity—handed *gratis* to Gorbachev—is the way in which we have played the SDI. There remains an almost universal concern in and out of governments in Western Europe that the impact of the SDI on the ABM Treaty could mess up opportunities for moving forward with arms control, which remains extremely important for Europeans.

Impact on NATO doctrine: fantasy and reality.

In addition to European public opinion, we must consider the impact of the SDI on NATO strategy and doctrine. Some of the impact is fantasy and some is real. The first fantasy is that somehow the SDI will make the continent safe for a replay of World War II. People are beginning to realize that it will never go that far because mutual assured destruction is going to continue. In fact, even if the SDI works 100 percent, mutual assured destruction will continue, so long as two conditions are fulfilled: One, the Soviet Union and the United States have nuclear weapons, and, two, they are in conflict with one another. Nothing we can do technologically is going to change that fact.

Other European concerns are more firmly based in reality. One such concern is that the SDI will contribute to a "decoupling" of U.S. and European security. The kind of shield that the President has proposed is seen by some Europeans as consistent with increased concerns about U.S. vulnerability and a desire for the United States to "leave the world fort." After all, it is insane for the United States to threaten suicide to defend Western Europe, but we do it. That's what we do despite what De Gaulle said, and so far it has worked.

There's also a concern that we may be in the process of jettisoning a doctrine that has worked—mutual assured destruction—and with it the coupling aspects of that doctrine for Western Europe, before there's anything to put in its place. Some

U.S. representatives are going around saying that because mutual assured destruction can't be believed in and flexible response doesn't have any real basis, we have to move to the SDI. These people are doing a huge disservice to the United States. If the SDI doesn't work and doesn't come into being tomorrow morning, the United States will have already communicated to the Europeans that there are circumstances in which it might not defend them. It's fine if Henry Kissinger wants to say it. He's not in government any more. But government officials have no right to say it.

Economic implications for Europe.

Economics are also very important in this debate, but that has been underplayed. If it went forward, the SDI would be very expensive. It would mean a diversion of U.S. economic product from conventional defense to strategic defense. For the Europeans, if they were to participate, it would also mean a diversion from conventional defense. We are already seeing new stirrings among those opposed to raising conventional defense spending in Western Europe—those opposed to the new follow-on forces attack (FOFA) doctrine. The SDI has played into their hands on economic as well as strategic grounds.

For Europe an important economic question is increasingly coming to the fore: Who gets the benefits of the SDI if it goes forward? Here our allies are on the horns of a dilemma, and that dilemma explains why the British and West Germans are willing to go along with the SDI up to a point. The implications of the SDI for our collective civilian economies for the next generation can be very important, particularly in the area of lasers and battle management computers. Many of our allies are worried about falling further and further behind the United States and Japan technologically, and they must ask themselves if they want to join the SDI with all of its diversions and difficulties or to stay outside and lose its benefits.

Views in West European capitals.

Let's take a quick tour of the views in major West European capitals. The French are staying outside of the SDI for strategic and economic reasons. They've come up with this thing called Eureka (European Research Agency), which is a civilian

Paris: Eureka.

alternative to the SDI. A seventeen-nation joint high-technology research program, Eureka is essentially a hollow shell. It's a way of trying to kill off our program and to force the West Germans into a tough decision.

London: Thatcher's four points.

The British felt that they had put the SDI back in its box when Prime Minister Margaret Thatcher was at Camp David and got the President's agreement to her famous four points. The most important of those points was that before the United States deploys SDI systems, we will have to have negotiations with the Soviets—in effect giving the Soviets a veto. Three days after Margaret Thatcher returned to London, the secretary of defense publicly disregarded that assurance. That, I think, helped provoke Britain's foreign secretary to lay out Britain's case against the SDI. Now I think the British are simply trying to outwait the SDI program. It is their belief that, by the time anything can really be deployed, the United States will understand the price tag, we will understand the strategic difficulties with it, and we'll have a new President.

Bonn: access to U.S. high technology.

West German Chancellor Helmut Kohl was even cleverer. Looking at the economic side, he said, "Well, if we do take part, we have to have access to your high technology." In effect he was saying, "Mr. President, you have to choose between those people in the Pentagon who don't want me to have high technology because they're afraid it's going to show up in Moscow, and having this new toy. Choose, Mr. President. You can't have it both ways."

To conclude, I think that whether or not one thinks the SDI is a good thing for the United States, whether or not it may eventually come into being, so far we have handled it just about as badly as we could. There are some real issues involved here for the Atlantic alliance that aren't just going to go away with a bit of soothing syrup.

SECOND SPEAKER: MAURICE EISENSTEIN *(Project Leader, the RAND Corporation)*

I would like to give another perspective regarding the Europeans and the SDI, perhaps one that is less cynical. To begin with, it's very clear that the SDI

impacts just about every aspect of NATO and U.S.-NATO relations and, indeed, will probably impact areas even tangential to U.S.-NATO relations over the years. While it's clear that the pursuit of an SDI program in the United States and in the Soviet Union will have a major impact on NATO defense strategy and doctrine, it will also have important implications for East-West relations. It will have economic implications stemming from the prospective development of new and exotic SDI technologies, and stemming from all of the above, there will be implications for domestic policies in some of the NATO countries.

Support for SDI R&D.

The implications of the SDI in the short term are primarily political and they are focused more on NATO concerns for the continuing arms control negotiations in Geneva on INF and on the implications for continuing INF deployments in NATO, especially in Holland and Belgium. For the moment, at least, the broader issues associated with deployment of the SDI have apparently been relegated to the back burner in most NATO capitals. That's not to say that the European capitals aren't concerned about the SDI, but rather that the SDI is now being seen as an R&D project, not necessarily yet as a deployment plan. I say this notwithstanding Gorbachev's attempts in recent months to bring SDI R&D and deployment front and center in the political dialogue of the European community. While Gorbachev may have made some gains in his attempts to raise and use the SDI issue to rattle the alliance, nonetheless, to most Europeans the SDI remains primarily an R&D program to be conducted within the ABM treaty.

Based on a number of indicators it appears that general support within Europe for the SDI has been growing. The return of the Soviets to Geneva arms control negotiations is now seen, at least in part, as the outcome of a vigorous U.S. SDI R&D program. SDI R&D has had growing and significant support within the United States, and particularly in the Congress. That has helped our position in Europe. Indeed, McNamara just a few weeks ago in a conference sponsored by SIPRI (the Stockholm International Peace Research Institute) in Sweden was sup-

portive of a U.S. R&D effort in ballistic missile defense, although he was not clear in his statement as to whether he agreed with the size or thrust of the current effort. I don't think there is any serious question either here or in Europe, as to whether the United States should pursue SDI R&D.

Contrasts between the SDI and INF debates in Europe.

It's interesting to observe that, in Europe, support or criticism of the SDI is not synonymous with support or criticism of the INF. Whereas in the INF debate the West European defense elite were by and large for the deployment of the INF, they have been almost universally against the deployment of the SDI. On the other hand, the general population in Europe seems to be supportive of the SDI. Whether or not they understand the SDI and all its ramifications is unclear, but unlike their almost overwhelming tendency to reject the INF, there is no such rejection for the SDI.

This, of course, could change if the Soviets succeed in stirring up public sentiment against the SDI or if the United States continues to make moves like the recent U.S. stand on the interpretation of the ABM Treaty. However, if no major American gaffes occur, the NATO nations will have more maneuver room in formulating their domestic policies relating to the SDI than they had with the INF.

Economic impact of the SDI on Europe.

In the longer term the implications of the SDI in NATO will depend on an assortment of factors, some of which are unrelated to the U.S. approach to deployment of strategic defenses. Thus, the economic implications of the SDI to the NATO nations have to do with the possibility that new, innovative technologies will be developed in America, leaving the West Europeans even further behind in the race to produce and export high-tech products. The magnitude of these economic implications from the SDI will be correlated with the size of the U.S. SDI R&D budget over the next decade. Of course, other economic concerns will descend upon NATO if a strategic defense system is ever deployed. It is much too early to predict the extent and scope of the economic impact that would result from possible changes in the U.S.-NATO force structure. They will depend on the specifics of the system deployed and the nature of any strategy and force changes undertaken by NATO.

Soviet reactions.

One can only guess what the implications for East-West relations will be, if the United States continues to pursue a high visibility SDI R&D program, even one that stays within the bounds of the ABM Treaty. The Soviets will no doubt become irate at U.S. SDI testing, particularly if they are not in a position to achieve their own comparable exhibitions in space. If they concentrate on or emphasize building their domestic economy over increased military spending in space for the next decade, numerous U.S. space tests could lead to perceptions of a change in the correlation of forces against them. They may feel pressures to pursue costly high-tech extravaganzas in space even if they cannot match what the United States does in the near term.

No doubt we can expect that the NATO governments and their populations will continue to be a major target for Soviet propaganda and disinformation, using the SDI as the potential ax to NATO solidarity.

Implications for NATO countries: facing criticism and resisting Soviet pressure.

In the realm of NATO domestic politics, each NATO nation will have its own special problems to contend with, given that U.S. and Soviet defenses might be deployed. The U.K. and French governments must face up to criticism and questions raised by the domestic opposition over the utility of projected improvements to their respective *force de frappe*; that is, will expensive planned improvements in nuclear weapons make the weapons viable, or will they become obsolete because the Soviets deploy extensive nationwide defenses. The West German government must be concerned that the Soviets will exert leverage on them through East-West German relations to renounce the U.S. SDI. And of course, there must be a concern that the European peace movement might be resurrected sometime in the future aimed specifically at the SDI, although as best as one can tell SDI R&D seems to have been accepted by some past members of the peace movement as a move toward reducing the nuclear peril.

There are other long-term implications for NATO stemming from deployment of a strategic defense, but they will depend on the details of what the

defenses are and whether or not there is some formal or informal cooperation between the United States and the Soviets in regulating their size and rate of deployment. It will matter to some extent to NATO whether the system is comprised of land-based or space-based defenses or both, whether it uses directed energy or kinetic energy weapons or both in its space defenses, and in what ratios of land and space the defenses will be. It will also rest on how well the defenses are expected to perform against Soviet missiles attacking NATO.

Long-term implications.

Will it be assured survival, a dome over the United States and over the Soviet Union, that is sought with the SDI? Or will it be, as it has been for many years, enhanced retaliation? Will it be the defense of our nuclear retaliatory assets or our national command authority that motivates the deployment of those defenses? Or will it be to deny the Soviet use of nuclear weapons to achieve a conventional military advantage? And of course, will the SDI also include comparably effective air defenses, or are we really talking about a defense system whose major component is ballistic missile defense? How well will it protect NATO? How well and against what kinds of threats? Will it require an underlay of ABMs to be deployed throughout NATO at great costs? Will it affect our options for controlled escalation and flexible response, the current basis of NATO strategy? Will it interfere with the ability of the U.K. and French forces to retaliate against the Soviet Union? Will it undermine the NATO countervailing strategy? What will the Soviet strategic defenses be able to defend against? These are just some of the questions that the Europeans are going to have to be concerned about in the future as the possible deployment of strategic defenses nears.

Developing defenses in two phases.

There are some who believe that it makes sense to develop strategic defenses in two phases: a first phase would be to strive for an effective defense against ballistic missiles, the more destabilizing of the elements of the strategic arsenals of both sides; and subsequent to that, if necessary, a thrust toward the deployment of defenses against other threats, that is, cruise missiles and aircraft. In all likelihood

air defense will be as expensive as strategic defenses and perhaps much more so. It might be a prescription which in the first instance would preclude the rational use of ballistic missiles and allow retaliatory strategies to continue, but with the use of the slower flying cruise missiles and bombers. This would not be a prescription for more conventional war, and it would answer the question for the Europeans as to whether or not they would be in a more exposed position to nuclear attack than either the United States or Soviet Union, if the SDI were to be all-encompassing in its defenses. That is, by the conclusion of the first phase, the Soviets, the United States, and NATO each would still be vulnerable to slower bomber and cruise missile escalation or retaliatory attack, but the United States and the Soviets would not be vulnerable to a concerted ballistic missile attack.

So there are a whole host of questions about the nature of the SDI and its impact on Europe. I don't think we yet see clearly what all of those effects might be and how our NATO allies would respond. Most important, we cannot readily predict what effect the SDI will have on the Geneva arms control negotiations over the longer haul and how the outcome of those negotiations could affect NATO interests.

Discussion

QUESTION:

Selling the SDI to Europe.

It is true that most of the defense elites in Europe are opposed to the SDI, although there are some who support it. But the opposition is not all that firm and is born of some confusion because the questions that Maurice Eisenstein raised have not yet been answered. There may be an opportunity for agreement in the future if those questions are answered. Perhaps the administration has not done a proper job in selling the SDI. How would you sell the SDI to Europe?

HUNTER:

If I were stuck with selling the SDI to Europe right now, I would say that strategic defense is something that we have to consider within the con-

text of deterrence, and that it may have some virtues, especially the defense of our retaliatory capability. If that is our objective, we need to see what aspects of the SDI can indeed enhance deterrence and stability, make the world a safer place, and in addition help make America's commitment to its allies more credible. I would tell the Europeans that we are talking about a research and development program that we have to do to keep up with the Soviets who have done a lot of R&D in this field—although they are not ten years ahead of us, as is asserted by the Pentagon.

Strategic defense should be considered in context of deterrence.

In addition, I would tell our allies that the United States will abide by the treaties we've already signed. We are not going to do feckless things like rushing into ASAT testing just before a summit. We are going to table some new positions in Geneva to keep arms control going. Furthermore, we will abide by the Camp David agreements with Margaret Thatcher because, quite obviously, we ourselves don't want to go beyond the research phase and jettison doctrines that have worked (although they may be imperfect), unless we are certain that something better has come along. We will start research on those things that are widely accepted as stabilizing, such as terminal defenses of land-based missile silos, but if we go in the direction of space-based systems, it's going to be sometime later on. We will evaluate the SDI in terms of the "coupling" question, the matter of the ATBM, the trade-offs with conventional defense, and what the Soviet reactions are. In effect, we should explain the SDI to our allies as something that we really ought to work on to see if it is possible; if it doesn't prove to be helpful to the alliance, we'll run away from it faster than they will.

EISENSTEIN:

For the longer-term question, this administration has already stated to the NATO allies that it would not deploy a defensive system without prior discussions with the Soviet Union. If we intended to deploy, we could do so in one of two ways. We could withdraw from the ABM Treaty with six months' notification, or we could sit down and

renegotiate that treaty with the Soviets. We've already made the commitment to consult on this with our NATO allies and with the Soviets as well. So I don't see that as a significant problem. We also may be committed to seek cooperative approaches to strategic defenses with the Soviet Union. Indeed I believe that makes a lot of sense.

The defenses that the administration and the Department of Defense are looking at extract a price, and the smaller the attack size, the smaller the defense size has to be. If the Soviets were to agree at Geneva to bring down significantly the number of their ballistic missile weapons, as they have offered to do, the cost of a strategic defense system would also come down significantly. If there were no SALT II and the undercut policy were eliminated and the Soviet Union were to double its strategic weapons force, the cost of a defensive system would go up comparably. Thus, it's in the interest of anybody who supports the SDI to pursue deep reductions in strategic offensive forces. Without deep reductions of strategic forces, in my judgment we will not achieve a defensive system anything like what the President has called for.

The need for deep cuts in offensive forces.

HUNTER:

Lots of people from the administration are going to Western Europe and saying, "Here's what the SDI is." There's only one person whose words count, and that's the President of the United States. He has said different things at different times. In a recent press conference, he said that the United States would continue with research, testing, and development, but not with deployment, which is not what the ABM Treaty says. If we're going to begin a process with the allies on such a neuralgic issue as nuclear weapons, then we have to sing from the same sheet of music.

EISENSTEIN:

Remember that we are only at the R&D stage of SDI. Thus, singing from one sheet of music is very hard to do. What is being said now is basically speculation.

QUESTION:

Impact on France and Germany.

I have a rather speculative question about how the SDI might affect relations between West Germany, France, and Great Britain. Let us assume no agreement is reached between the United States and the Soviet Union, so the United States proceeds with SDI R&D. West Germany and Great Britain agree to come in on it, but France does not. Eventually Great Britain and West Germany will have the beginnings of a credible defense against nuclear weapons, whereas France will not. The French might see this as an erosion of their position in Europe. What might the French do at that point?

EISENSTEIN:

The French are not above asking for help. They have in the past. My gut guess is that if they found their strategic position deteriorating, with reasonable probability the United States would work out some arrangement to assist them. Of course, it is not clear whether or not ATBMs are desirable to have in NATO. The situation in Europe is the reverse of the situation in the United States. In the United States we are talking about a defensive system which would not keep out bombers. We have argued that air defenses are meaningless in the United States because we're vulnerable to ballistic missiles. In Europe we're pushing like hell to build bomber defenses when in fact they are easily vulnerable to Soviet nuclear ballistic missiles.

HUNTER:

Your scenario goes too far. If, indeed, the SDI goes forward on the Soviet as well as the American side, things will be worked out in the alliance one way or the other and France will be part of it.

Implicit in what you're saying is a question about whether the West Germans will go along with us or with France. They are going to do whatever they have to do in order not to choose. French President Francois Mitterrand put out this Eureka idea to try to sidetrack the SDI and to highlight the economic problems. Chancellor Kohl said, "I have to choose between the SDI and Eureka, and I choose them

both." In fact, it might be that Mitterrand did more to get the West Germans to participate in SDI research than anything we did because, if he hadn't, it would have looked like he was choosing the French over us.

EISENSTEIN:

Impact on flexible response.

I want to be on the record on the implications of the SDI to NATO's strategy of flexible response and escalation control. I think the issue has to be addressed in the context of what future defenses look like. I don't think we can just simply wave our arms and say that the SDI will introduce great uncertainties in the ability of the NATO alliance to implement the flexible response strategy. The flexible response strategy depends on cruise missiles and aircraft-delivered weapons as well as ballistic missiles. Even with a strategic defense system, the Soviet Union could not defend itself any better than it can today against a cruise missile launched from central Europe. So yes, there are some implications, but flexible response can still be a viable mission for NATO even if the Soviets put in very extensive space-based and land-based ABMs.

QUESTION:

The new interpretation of the ABM Treaty.

I would like to go back to Mr. Holmes's statement and ask your opinion of the administration's new ABM Treaty interpretation.

EISENSTEIN:

The major objective of this new ABM Treaty interpretation may be to lay a marker down for either the 1986 summit meeting between Reagan and Gorbachev or the Geneva negotiations. Identifying a possible looser interpretation of the ABM Treaty could suggest to the Soviets that they might resolve those ambiguities, lest the United States take advantage of them in ways that they themselves might not be able to.

HUNTER:

I'm prepared to accept your interpretation, but if it is correct, I'm even more worried than I was before about U.S. preparations for the summit. What's going on is a battle for hearts and minds in

Western Europe, and the United States is losing it. As an American who thinks we have good cards and who thinks Gorbachev is just as mean and nasty as the rest of them, this distresses me. We introduced this ABM compliance issue, and in doing so we shot ourselves right square in the foot. The mess has been cleaned up now, but you just wonder who's tending the store.

Deterrence strategy should not be undercut.

I'll make Jim Holmes a deal. Jim, I'll say that maybe we should wait and see what the SDI produces before arriving at any conclusions. I'll go along with that if people in the administration will stop undercutting confidence in Europe by saying that flexible response is dead and must be replaced or that mutual assured destruction is not credible, and if you find a way to stop those people in the administration who want to keep certain questions open precisely to get to the point where it is too late to turn back. If you will allow me those two things, I'll be delighted, but I don't think you can deliver on your half of the deal.

HOLMES:

I would agree that we certainly should not do or say those things which undercut current deterrent postures and policies until we have had an opportunity to determine whether or not we will have something better for the future.

Biographic Material on Speakers

Hans Binnendijk

Dr. Binnendijk, who organized the SDI symposium and edited this volume, is Director of the Center for the Study of Foreign Affairs of the Foreign Service Institute.

From 1981 to 1984, he was Deputy Staff Director and Legislative Director for the Senate Foreign Relations Committee. He served three Senate Foreign Relations Committee chairmen, from 1977 to 1984, as an advisor on international security policy, arms control, and foreign aid. Dr. Binnendijk was also a foreign policy advisor to Senator Charles Mathias, a staff member of the National Security Council, an examiner at the Office of Management and Budget, and an analyst at the Congressional Research Service. He has taught courses at Georgetown University and Sophia University in Tokyo and has published numerous articles on international relations.

James A. Abrahamson

Lieutenant General Abrahamson is Director of the Strategic Defense Initiative Organization (SDIO) in the Department of Defense, a position he has held since April 1984. He is responsible for the nation's research and technology programs relating to defense against ballistic missiles.

From 1981 to 1984, General Abrahamson was Associate Administrator for the Space Transportation System at the headquarters of the National Aeronautics and Space Administration in Washington. He was responsible for the Space Shuttle Program and guided the program into the operational era.

General Abrahamson has had a long and distinguished career with the Air Force, beginning with his commission as second lieutenant in 1955, through two tours of duty in Southeast Asia—where he flew 49 combat missions—and continuing with his selection as astronaut with the Air Force's Manned Orbiting Laboratory Program until the program's cancellation in 1969. In 1974, General Abrahamson was named Inspector General for Air Force Systems Command at Andrews Air Force Base. In 1980, he became Deputy Chief of Staff for Systems of Air Force Systems Command Headquarters.

Alex Gliksman

Mr. Gliksman is Director of Strategic Defense Studies for the United Nations Association of the U.S.A. His research and writings on the arms control and international security implications of strategic defenses and antisatellite weapons are supported by a grant from the Carnegie Corporation of New York. He is also a consultant to the Congressional Office of Technology Assessment, Sandia National Laboratory, Lawrence Livermore

National Laboratory, and Systems Planning Corporation.

From 1982 to 1985, Mr. Gliksman directed the U.S. Senate Foreign Relations Arms Control Subcommittee staff. He is a contributing editor of *National Defense* and a frequent contributor to the *Christian Science Monitor's* opinion page, and his writings have frequently appeared in the national press and in leading foreign affairs and defense journals.

Gerold Yonas

Dr. Yonas is Chief Scientist and Acting Deputy Director of the Strategic Defense Initiative Organization (SDIO). Before joining the SDIO, he was Director of Pulsed Power Sciences at Sandia National Laboratories. His responsibilities included development and application of intense electron and ion beams, high power microwaves, lasers, high density plasma, and radiation source and energy conversion devices.

Prior to his work at Sandia, he directed research on high current electron beams at Physics International Company. While completing his doctorate at the California Institute of Technology, Dr. Yonas was employed as a scientist at the Jet Propulsion Laboratory where he investigated magnet fluid dynamics.

Dr. Yonas has served as an advisor to several government agencies and has published extensively in the field of intense particle beam and inertial confinement fusion. In 1983, he served as Chairman of the Directed Energy Weapon Panel for the Defense Technology Study Team which prepared the plan now being pursued by the SDIO.

Edward R. Gerry

Since 1975, Dr. Gerry has served as President of W.J. Schafer Associates, Inc. (WJSA).

During the summer of 1983, Dr. Gerry served as chairman, Boost Phase System Concepts, for the Defensive Technologies Study Team (DTST) which reviewed the technology for multi-tier ballistic missile defense in response to President Reagan's March 23, 1983, Strategic Defense Initiative.

Before joining WJSA, Dr. Gerry served as Assistant Director for Technology in the Strategic Technology Office of the Defense Advanced Research Projects Agency (DARPA) where he was responsible for DARPA's activities in space surveillance and identification, advanced space-based surveillance optics and sensors, and high energy laser technology. Earlier, as Chief of the Laser Technology Division, he was responsible for the technical management and programming of DARPA's research and development activities in high-power laser devices, materials and components.

Peter Sharfman

Dr. Sharfman is currently Program Manager for International Security and Commerce Programs, Office of Technology Assessment of the U.S. Congress.

From 1976 to 1978, he was Assistant Director of Net Assessment, Office of the Secretary of Defense, and from 1971 to 1976, he worked in the Foreign Affairs Office of the Arms Control and Disarmament Agency.

Lawrence K. Gershwin

Dr. Gershwin is currently National Intelligence Officer for Strategic Programs at the Central Intelligence Agency, a position he has held since 1981.

From 1979 to 1981, he served in the Office of the Secretary of Defense, Program Analyses and Evaluation, with responsibilities in strategic force analysis, arms control, and net assessments.

Earlier Dr. Gershwin was with the RAND Corporation, performing studies for the Department of Defense on comparison of U.S. and Soviet land warfare systems, strategic conflict, and Soviet strategic forces. He also performed several studies for the Department of Defense on advanced technology systems for conventional and nuclear warfare at the Institute for Defense Analyses.

Sayre Stevens

Dr. Stevens is currently President of the National Security Research Group of the Systems Planning Corporation and a former member of the Defense Science Board.

From 1957 to 1979, Dr. Stevens served in the Central Intelligence Agency, holding a number of positions involving technical intelligence analysis and research and development. As Deputy Director for Intelligence he was responsible for all of the agency's intelligence analysis. He served as advisor to the SALT I delegation.

Among his many works on ballistic missile defense are "The Soviet BMD Program" in *Ballistic Missile Defense*, edited by Ashton B. Carter and David N. Schwartz (Washington, DC: The Brookings Institution, 1984) and "Ballistic Missile Defense in the Soviet Union," *Current History* (October 1985).

Gerard C. Smith

Mr. Smith is President of the Consultants International Group and Chairman of the Board of the Arms Control Association.

From 1977-1980, Mr. Smith was Ambassador-at-Large and Presidential Special Representative for Non-Proliferation. In 1981 he was awarded the Presidential Medal of Freedom, the nation's highest civilian award. From 1970-1973, Mr. Smith was Director of the Arms Control and Disarmament Agency and Chief of the SALT I delegation. His book, *Doubletalk, the Story of SALT I*, was published by Doubleday in 1980.

Dan Quayle

Senator Quayle of Indiana serves on the Senate Armed Services Committee and is Chairman of the Defense Acquisition Policy Subcommittee. He also serves on the Armed Services Subcommittees on Military Con-

struction, on Sea Power and Force Projection, and on Strategic and Theatre Nuclear Forces.

James H. Holmes

Mr. Holmes is currently Director of the Office of Strategic Nuclear Policy of the Bureau for Political and Military Affairs of the State Department.

In 1984, Mr. Holmes was a graduate of the National War College. From 1973 to 1976 he served on the White House staff. Mr. Holmes has been a Foreign Service Officer since 1967, serving in Pakistan, New Zealand, and Norway.

Leon Sloss

Mr. Sloss is President of Leon Sloss Associates, a Washington-based consulting firm which conducts studies for government and the private sector on national security policy issues. He is also chairman of a study group, established by the Department of Defense, which examines issues related to U.S. nuclear policy.

From 1982 to 1983, he served on two Defense Department advisory committees which examined new approaches to ballistic missile defense—the Foster Panel and the Hoffman Panel. From 1979 until 1981, Mr. Sloss was Vice President and head of the Washington office of SRI International. During the 1970s, he held senior positions in the State Department, the Department of Defense, and the Arms Control and Disarmament Agency.

Among his many works are "U.S. Nuclear Strategy in Evolution," co-authored with Marc Dean Millot, in *Strategic Review* and "The Return of Strategic Defense," published in the same journal.

Walter Slocombe

Mr. Slocombe has been a member of the Washington, D.C., law firm of Caplin and Drysdale since 1981. He is also an Adjunct Fellow of the Georgetown University Center for Strategic and International Studies and co-chairman of its Group on Strategy and Arms Control.

From 1979-1981 he served as Deputy Under Secretary of Defense for Policy Planning and Director of the Department of Defense SALT Task Force, and from 1977 to 1979 as Principal Deputy Assistant Secretary of Defense for International Security Affairs and Department of Defense SALT Task Force Director.

Mr. Slocombe is author of *The Political Implications of Strategic Parity* (an Institute for International Strategic Studies' Adelphi Paper) and other papers and articles on defense policy. He has served as a consultant to the RAND Corporation and as a member of the Advisory Panel for the Office of Technology Assessment.

Robert Hunter

Dr. Hunter is currently the Director of European Studies and Senior Fellow in Middle East Studies at Georgetown's Center for Strategic and

International Studies. He is also a contributing editor to the *Washington Quarterly*.

Dr. Hunter was Special Advisor to the Speaker of the House of Representatives on Lebanon and Lead Consultant of the National Bipartisan Commission on Central America (the Kissinger Commission). During the Carter Administration, he served on the National Security Council staff as Director of West European Affairs from 1977 to 1979 and Director of Middle East Affairs from 1979 to 1981.

Maurice Eisenstein

Mr. Eisenstein is currently a Project Leader and Senior Staff member for the RAND Corporation in Washington.

Prior to this position, in 1985 and 1984, he served with the Arms Control and Disarmament Agency as a representative to the START negotiations.

Appendices

The Conclusion of President Reagan's March 23, 1983, Speech on Defense Spending and Defensive Technology

Now, thus far tonight I've shared with you my thoughts on the problems of national security we must face together. My predecessors in the Oval Office have appeared before you on other occasions to describe the threat posed by Soviet power and have proposed steps to address that threat. But since the advent of nuclear weapons, those steps have been increasingly directed toward deterrence of aggression through the promise of retaliation.

This approach to stability through offensive threat has worked. We and our allies have succeeded in preventing nuclear war for more than three decades. In recent months, however, my advisers, including in particular the Joint Chiefs of Staff, have underscored the necessity to break out of a future that relies solely on offensive retaliation for our security.

Over the course of these discussions, I've become more and more deeply convinced that the human spirit must be capable of rising above dealing with other nations and human beings by threatening their existence. Feeling this way, I believe we must thoroughly examine every opportunity for reducing tensions and for introducing greater stability into the strategic calculus on both sides.

One of the most important contributions we can make is, of course, to lower the level of all arms, and particularly nuclear arms. We're engaged right now in several negotiations with the Soviet Union to bring about a mutual reduction of weapons. I will report to you a week from tomorrow my thoughts on that score. But let me just say, I'm totally committed to this course.

If the Soviet Union will join with us in our effort to achieve major arms reduction, we will have succeeded in stabilizing the nuclear balance. Nevertheless, it will still be necessary to rely on the specter of retaliation, on mutual threat. And that's a sad commentary on the human condition. Wouldn't it be better to save lives than to avenge them? Are we not capable of demonstrating our peaceful intentions by applying all our abilities and our ingenuity to achieving a truly lasting stability? I think we are. Indeed, we must.

After careful consultation with my advisers, including the Joint Chiefs of Staff, I believe there is a way. Let me share with you a vision of the future which offers hope. It is that we embark on a program to counter the awesome Soviet missile threat with measures that are defensive. Let us turn to the very strengths in technology that spawned our great industrial base and that have given us the quality of life we enjoy today.

What if free people could live secure in the knowledge that their security did not rest upon the threat of instant U.S. retaliation to deter a Soviet attack, that we could intercept and destroy strategic ballistic missiles before they reached our own soil or that of our allies?

I know this is a formidable, technical task, one that may not be accomplished before the end of this century. Yet, current technology has attained a level of sophistication where it's reasonable for us to begin this effort. It will take years, probably decades of effort on many fronts. There will be failures and setbacks, just as there will be successes and breakthroughs. And as we proceed, we must remain constant in preserving the nuclear deterrent and maintaining a solid capability for flexible response. But isn't it worth every investment necessary to free the world from the threat of nuclear war? We know it is.

In the meantime, we will continue to pursue real reductions in nuclear arms, negotiating from a position of strength that can be ensured only by modernizing our strategic forces. At the same time, we must take steps to reduce the risk of a conventional military conflict escalating to nuclear war by improving our non-nuclear capabilities.

America does possess — now — the technologies to attain very significant improvements in the effectiveness of our conventional, non-nuclear forces. Proceeding boldly with these new technologies, we can significantly reduce any incentive that the Soviet Union may have to threaten attack against the United States or its allies.

As we pursue our goal of defensive technologies, we recognize that our allies rely upon our strategic offensive power to deter attacks against them. Their vital interests and ours are inextricably linked. Their safety and ours are one. And no change in technology can or will alter that reality. We must and shall continue to honor our commitments.

I clearly recognize that defensive systems have limitations and raise certain problems and ambiguities. If paired with offensive systems, they can be viewed as fostering an aggressive policy, and no one wants that. But with these considerations firmly in mind, I call upon the scientific community in our country, those who gave us nuclear weapons, to turn their great talents now to the cause of mankind and world peace, to give us the means of rendering these nuclear weapons impotent and obsolete.

Tonight, consistent with our obligations of the ABM treaty and recognizing the need for closer consultation with our allies, I'm taking an important first step. I am directing a comprehensive and intensive effort to define a long-term research and development program to begin to achieve our ultimate goal of eliminating the threat posed by strategic nuclear missiles. This could pave the way for arms control measures to eliminate the weapons themselves. We seek neither military superiority nor political advantage. Our only purpose — one all people share — is to search for ways to reduce the danger of nuclear war.

My fellow Americans, tonight we're launching an effort which holds the promise of changing the course of human history. There will be risks, and results take time. But I believe we can do it. As we cross this threshold, I ask for your prayers and your support.

Thank you, good night, and God bless you.

Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems

Signed at Moscow May 26, 1972
Ratification advised by U.S. Senate August 3, 1972
Ratified by U.S. President September 30, 1972
Proclaimed by U.S. President October 3, 1972
Instruments of ratification exchanged October 3, 1972
Entered into force October 3, 1972

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Proceeding from the premise that nuclear war would have devastating consequences for all mankind,

Considering that effective measures to limit anti-ballistic missile systems would be a substantial factor in curbing the race in strategic offensive arms and would lead to a decrease in the risk of outbreak of war involving nuclear weapons,

Proceeding from the premise that the limitation of anti-ballistic missile systems, as well as certain agreed measures with respect to the limitation of strategic offensive arms, would contribute to the creation of more favorable conditions for further negotiations on limiting strategic arms,

Mindful of their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons,

Declaring their intention to achieve at the earliest possible date the cessation of the nuclear arms race and to take effective measures toward reductions in strategic arms, nuclear disarmament, and general and complete disarmament,

Desiring to contribute to the relaxation of international tension and the strengthening of trust between States,

Have agreed as follows:

Article I

1. Each party undertakes to limit anti-ballistic missile (ABM) systems and to adopt other measures in accordance with the provisions of this Treaty.

2. Each Party undertakes not to deploy ABM systems for a defense of the territory of its country and not to provide a base for such a defense, and not to deploy ABM systems for defense of an individual region except as provided for in Article III of this Treaty.

Article II

1. For the purpose of this Treaty an ABM system is a system to counter strategic ballistic missiles or their elements in flight trajectory, currently consisting of:

(a) ABM interceptor missiles, which are interceptor missiles constructed and deployed for an ABM role, or of a type tested in an ABM mode;

(b) ABM launchers, which are launchers constructed and deployed for launching ABM interceptor missiles; and

(c) ABM radars, which are radars constructed and deployed for an ABM role, or of a type tested in an ABM mode.

2. The ABM system components listed in paragraph 1 of this Article include those which are:

(a) operational;
(b) under construction;
(c) undergoing testing;
(d) undergoing overhaul, repair or conversion; or
(e) mothballed.

Article III

Each Party undertakes not to deploy ABM systems or their components except that:

(a) within one ABM system deployment area having a radius of one hundred and fifty kilometers and centered on the Party's national capital, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, and (2) ABM radars within no more than six ABM radar complexes, the area of each complex being circular and having a diameter of no more than three kilometers; and

(b) within one ABM system deployment area having a radius of one hundred and fifty kilometers and containing ICBM silo launchers, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, (2) two large phased-array ABM radars comparable in potential to corresponding ABM radars operational or under construction on the date of signature of the Treaty in an ABM system deployment area containing ICBM silo launchers, and (3) no more than eighteen ABM radars each having a potential less than the potential of the smaller of the above-mentioned two large phased-array ABM radars.

Article IV

The limitations provided for in Article III shall not apply to ABM systems or their components used for development or testing, and located within current or additionally agreed test ranges. Each Party may have no more than a total of fifteen ABM launchers at test ranges.

Article V

1. Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, air-based, space-based, or mobile land-based.

2. Each Party undertakes not to develop, test, or deploy ABM launchers for launching more than one ABM interceptor missile at a time from each launcher, not to modify deployed launchers to provide them with such a capability, not to develop, test, or deploy automatic or semi-automatic or other similar systems for rapid reload of ABM launchers.

Article VI

To enhance assurance of the effectiveness of the limitations on ABM systems and their components provided by the Treaty, each Party undertakes:

(a) not to give missiles, launchers, or radars, other than ABM interceptor missiles, ABM launchers, or ABM radars, capabilities to counter strategic ballistic missiles or their elements in flight trajectory, and not to test them in an ABM mode; and

(b) not to deploy in the future radars for early warning of strategic ballistic missile attack except at locations along the periphery of its national territory and oriented outward.

Article VII

Subject to the provisions of this Treaty, modernization and replacement of ABM systems or their components may be carried out.

Article VIII

ABM systems or their components in excess of the numbers or outside the areas specified in this Treaty, as well as ABM systems or their components prohibited by this Treaty, shall be destroyed or dismantled under agreed procedures within the shortest possible agreed period of time.

Article IX

To assure the viability and effectiveness of this Treaty, each Party undertakes not to transfer to other States, and not to deploy outside its national territory, ABM systems or their components limited by this Treaty.

Article X

Each Party undertakes not to assume any international obligations which would conflict with this Treaty.

Article XI

The Parties undertake to continue active negotiations for limitations on strategic offensive arms.

Article XII

1. For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.

2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.

3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

Article XIII

1. To promote the objectives and implementation of the provisions of this Treaty, the Parties shall establish promptly a Standing Consultative Commission, within the framework of which they will:

(a) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;

(b) provide on a voluntary basis such information as either Party considers necessary to assure confidence in compliance with the obligations assumed;

(c) consider questions involving unintended interference with national technical means of verification;

(d) consider possible changes in the strategic situation which have a bearing on the provisions of this Treaty;

(e) agree upon procedures and dates for destruction or dismantling of ABM systems or their components in cases provided for by the provisions of this Treaty;

(f) consider, as appropriate, possible proposals for further increasing the viability of this Treaty; including proposals for amendments in accordance with the provisions of this Treaty;

(g) consider, as appropriate, proposals for further measures aimed at limiting strategic arms.

2. The Parties through consultation shall establish, and may amend as appropriate, Regulations for the Standing Consultative Commission governing procedures, composition and other relevant matters.

Article XIV

1. 1. Each Party may propose amendments to this Treaty. Agreed amendments shall enter into force in accordance with the procedures governing the entry into force of this Treaty.

2. Five years after entry into force of this Treaty, and at five-year intervals thereafter, the Parties shall together conduct a review of this Treaty.

Article XV

1. This Treaty shall be of unlimited duration.

2. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from the Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

Article XVI

1. This Treaty shall be subject to ratification in accordance with the constitutional procedures of each Party. The Treaty shall enter into force on the day of the exchange of instruments of ratification.

2. This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

DONE at Moscow on May 26, 1972, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA	FOR THE UNION OF SOVIET SOCIALIST REPUBLICS
President of the United States of America	General Secretary of the Central Committee of the CPSU

Agreed Statements, Common Understandings, and Unilateral Statements Regarding the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missiles

1. Agreed Statements

The document set forth below was agreed upon and initialed by the Heads of the Delegations on May 26, 1972 (letter designations added):

AGREED STATEMENTS REGARDING THE TREATY BETWEEN THE UNITED STATES OF AMERICA AND THE UNION OF SOVIET SOCIALIST REPUBLICS ON THE LIMITATION OF ANTI-BALLISTIC MISSILE SYSTEMS

[A]

The Parties understand that, in addition to the ABM radars which may be deployed in accordance with subparagraph (a) of Article III of the Treaty, those non-phased-array ABM radars operational on the date of signature of the Treaty within the ABM system deployment area for defense of the national capital may be retained.

[B]

The Parties understand that the potential (the product of mean emitted power in watts and antenna area in square meters) of the smaller of the two large phased-array ABM radars referred to in subparagraph (b) of Article III of the Treaty is considered for purposes of the Treaty to be three million.

[C]

The Parties understand that the center of the ABM system deployment area centered on the national capital and the center of the ABM system deployment area containing ICBM silo launchers for each Party shall be separated by no less than thirteen hundred kilometers.

[D]

In order to insure fulfillment of the obligation not to deploy ABM systems and their components except as provided in Article III of the Treaty, the Parties agree that in the event ABM systems based on other physical principles

and including components capable of substituting for ABM interceptor missiles, ABM launchers, or ABM radars are created in the future, specific limitations on such systems and their components would be subject to discussion in accordance with Article XIII and agreement in accordance with Article XIV of the Treaty.

[E]

The Parties understand that Article V of the Treaty includes obligations not to develop, test or deploy ABM interceptor missiles for the delivery by each ABM interceptor missile of more than one independently guided warhead.

[F]

The Parties agree not to deploy phased-array radars having a potential (the product of mean emitted power in watts and antenna area in square meters) exceeding three million, except as provided for in Articles III, IV and VI of the Treaty, or except for the purposes of tracking objects in outer space or for use as national technical means of verification.

[G]

The Parties understand that Article IX of the Treaty includes the obligation of the US and the USSR not to provide to other States technical descriptions or blue prints specially worked out for the construction of ABM systems and their components limited by the Treaty.

2. Common Understandings

Common understanding of the Parties on the following matters was reached during the negotiations:

A. Location of ICBM Defenses

The U.S. Delegation made the following statement on May 26, 1972:

Article III of the ABM Treaty provides for each side one ABM system deployment area centered on its national capital and one ABM system deployment area containing ICBM silo launchers. The two sides have registered agreement on the following statement: "The Parties understand that the center of the ABM system deployment area centered on the national capital and the center of the ABM system deployment area containing ICBM silo launchers for each Party shall be separated by no less than thirteen hundred kilometers." In this connection, the U.S. side notes that its ABM system deployment area for defense of ICBM silo launchers, located west of the Mississippi River, will be centered in the Grand Forks ICBM silo launcher deployment area. (See Agreed Statement [C].)

B. ABM Test Ranges

The U.S. Delegation made the following statement on April 26, 1972:

Article IV of the ABM Treaty provides that "the limitations provided for in Article III shall not apply to ABM systems or their components used for development or testing, and located within current or additionally agreed test ranges." We believe it would be useful to asssure that there is no misunderstanding as to current ABM test ranges. It is our understanding that

ABM test ranges encompass the area within which ABM components are located for test purposes. The current U.S. ABM test ranges are at White Sands, New Mexico, and at Kwajalein Atoll, and the current Soviet ABM test range is near Sary Shagan in Kazakhstan. We consider that non-phased array radars of types used for range safety or instrumentation purposes may be located outside of ABM test ranges. We interpret the reference in Article IV to "additionally agreed test ranges" to mean that ABM components will not be located at any other test ranges without prior agreement between our Governments that there will be such additional ABM test ranges.

On May 5, 1972, the Soviet Delegation stated that there was a common understanding on what ABM test ranges were, that the use of the types of non-ABM radars for range safety or instrumentation was not limited under the Treaty, that the reference in Article IV to "additionally agreed" test ranges was sufficiently clear, and that national means permitted identifying current test ranges.

C. Mobile ABM Systems

On January 29, 1972, the U.S. Delegation made the following statement:

Article V(1) of the Joint Draft Text of the ABM Treaty includes an undertaking not to develop, test, or deploy mobile land-based ABM systems and their components. On May 5, 1971, the U.S. side indicated that, in its view, a prohibition on deployment of mobile ABM systems and components would rule out the deployment of ABM launchers and radars which were not permanent fixed types. At that time, we asked for the Soviet view of this interpretation. Does the Soviet side agree with the U.S. side's interpretation put forward on May 5, 1971?

On April 13, 1972, the Soviet Delegation said there is a general common understanding on this matter.

D. Standing Consultative Commission

Ambassador Smith made the following statement on May 22, 1972:

The United States proposes that the sides agree that, with regard to initial implementation of the ABM Treaty's Article XIII on the Standing Consultative Commission (SCC) and of the consultation Articles to the Interim Agreement on offensive arms and the Accidents Agreement[1], agreement establishing the SCC will be worked out early in the follow-on SALT negotiations; until that is completed, the following arrangements will prevail: when SALT is in session, any consultation desired by either side under these Articles can be carried out by the two SALT Delegations; when SALT is not in session, *ad hoc* arrangements for any desired consultations under these Articles may be made through diplomatic channels.

Minister Semenov replied that, on an *ad referendum* basis, he could agree that the U.S. statement corresponded to the Soviet understanding.

E. Standstill

On May 6, 1972, Minister Semenov made the following statement:

In an effort to accommodate the wishes of the U.S. side, the Soviet Delegation is prepared to proceed on the basis that the two sides will in fact observe the obligations of both the Interim Agreement and the ABM

Treaty beginning from the date of signature of these two documents.

In reply, the U.S. Delegation made the following statement on May 20, 1972:

The U.S. agrees in principle with the Soviet statement made on May 6 concerning observance of obligations beginning from date of signature but we would like to make clear our understanding that this means that, pending ratification and acceptance, neither side would take any action prohibited by the agreements after they had entered into force. This understanding would continue to apply in the absence of notification by either signatory of its intention not to proceed with ratification or approval.

The Soviet Delegation indicated agreement with the U.S. statement.

3. Unilateral Statements

The following noteworthy unilateral statements were made during the negotiations by the United States Delegation:

A. Withdrawal from the ABM Treaty

On May 9, 1972, Ambassador Smith made the following statement:

The U.S. Delegation has stressed the importance the U.S. Government attaches to achieving agreement on more complete limitations on strategic offensive arms, following agreement on an ABM Treaty and on an Interim Agreement on certain measures with respect to the limitation of strategic offensive arms. The U.S. Delegation believes that an objective of the follow-on negotiations should be to constrain and reduce on a long-term basis threats to the survivability of our respective strategic realiatory forces. The USSR Delegation has also indicated that the objectives of SALT would remain unfulfilled without the achievement of an agreement providing for more complete limitations on strategic offensive arms. Both sides recognize that the initial agreements would be steps toward the achievement of more complete limitations on strategic arms. If an agreement providing for more complete strategic offensive arms limitations were not achieved within five years, U.S. supreme interests could be jeopardized. Should that occur, it would constitute a basis for withdrawal from the ABM Treaty. The U.S. does not wish to see such a situation occur, nor do we believe that the USSR does. It is because we wish to prevent such a situation that we emphasize the importance the U.S.

Government attaches to achievement of more complete limitations on strategic offensive arms. The U.S. Executive will inform the Congress, in connection with Congressional consideration of the ABM Treaty and the Interim Agreement, of this statement of the U.S. position.

B. Tested in ABM Mode

On April 7, 1972, the U.S. Delegation made the following statement:

Article II of the Joint Text Draft uses the term "tested in an ABM mode," in defining ABM components, and Article VI includes certain obligations concerning such testing. We believe that the sides should have a common understanding of this phrase. First, we would note that the testing provisions of the ABM Treaty are intended to apply to

testing which occurs after the date of signature of the Treaty, and not to any testing which may have occurred in the past. Next, we would amplify the remarks we have made on this subject during the previous Helsinki phase by setting forth the objectives which govern the U.S. view on the subject, namely, while prohibiting testing of non-ABM components for ABM purposes: not to prevent testing of ABM components, and not to prevent testing of non-ABM components for non-ABM purposes. To clarify our interpretation of "tested in an ABM mode," we note that we would consider a launcher, missile or radar to be "tested in an ABM mode" if, for example, any of the following events occur: (1) a launcher is used to launch an ABM interceptor missile, (2) an interceptor missile is flight tested against a target vehicle which has a flight trajectory with characteristics of a strategic ballistic missile flight trajectory, or is flight tested in conjunction with the test of an ABM interceptor missile or an ABM radar at the same test range, or is flight tested to an altitude inconsistent with interception of targets against which air defenses are deployed, (3) a radar makes measurements on a cooperative target vehicle of the kind referred to in item (2) above during the reentry portion of its trajectory or makes measurements in conjunction with the test of an ABM interceptor missile or an ABM radar at the same test range. Radars used for purposes such as range safety or instrumentation would be exempt from application of these criteria.

C. No-Transfer Article of ABM Treaty

On April 18, 1972, the U.S. Delegation mae the following statement:

In regard to this Article [IX], I have a brief and I believe self-explanatory statement to make. The U.S. side wishes to make clear that the provisions of this Article do not set a precedent for whatever provision may be considered for a Treaty on Limiting Strategic Offensive Arms. The question of transfer of strategic offensive arms is a far more complex issue, which may require a different solution.

D. No Increase in Defense of Early Warning Radars

On July 28, 1970, the U.S. Delegation made the following statement:

Since Hen House radars [Soviet ballistic missile early warning radars] can detect and track ballistic missile warheads at great distances, they have a significant ABM potential. Accordingly, the U.S. would regard any increase in the defenses of such radars by surface-to-air missiles as inconsistent with an agreement.

Strategic Defense Initiative Glossary

(A guide to technical terms for use as a reference in understanding articles on and discussions of the SDI.)

Ablative Shield A shield that evaporates when heated, absorbing laser energy and protecting the object which is behind it from heat damage.

Ablative Shock Generation of a mechanical shock wave at the surface of an object exposed to intense pulsed electromagnetic radiation. A thin layer of the object's surface violently and rapidly boils off; the resulting vapor suddenly exerts pressure against the surface, generating a mechanical shock wave. This wave then propogates deeper into the object and can cause melting, vaporization, and spallation of surface material and structural failure of the object.

ABM System Antiballistic missile, a system to counter strategic ballistic missiles or their elements during flight.

Acquisition Detection of a potential target by the sensors of a weapons system.

Active Sensor One that illuminates a target, producing return secondary radiation, which is then detected in order to track and/or identify the target.

Adaptive Optics Optical systems which can be modified (e.g., by controlling the shape of a mirror) to compensate for distortions. An example is the use of information from a beam of light, passing through the atmosphere to compensate for the distortion suffered by another beam of light on its passage through the atmosphere. Used to eliminate the "twinkling" of stars in observational astronomy and to reduce the dispersive effect of the atmosphere on laser beam weapons.

Air-Borne Optical Adjunct A set of sensors designed to detect, track, and discriminate an incoming warhead. The sensors are typically optical or infrared devices flown in an aircraft stationed above clouds.

Air-Breathing Describing a flying weapon that travels through the atmosphere and uses air in its propulsion system. Examples are jet aircraft and cruise missiles. Specifically does not include ballistic missiles.

Analog Processing Problem solving in a computer by means of direct manipulation of the magnitudes of a physical quantity. For example, the sizes of different voltage pulses may be compared, added, subtracted, etc., in the course of solving a problem.

This glossary is a compilation of glossaries found in the following government publications: *Anti-Satellite Weapons, Countermeasures, and Arms Control* (Office of Technology Assessment, 1985), *Ballistic Missile Defense Technologies* (Office of Technology Assessment, 1985), *Security and Arms Control: The Search for a More Stable Peace* (Bureau of Public Affairs, Department of State, 1984), and *The Strategic Defense Initiative: Defensive Technologies Study* (Department of Defense, 1984).

Anti-Satellite Weapon (ASAT) A weapon to destroy satellites in space.

Anti-Simulation Deceiving adversary sensors by making a strategic target look like a decoy.

Area Defense An ABM defense covering a large area. Usually implies the capability to protect "soft" (i.e., not hardened missile silos or bunkers) targets.

Architecture The physical structure of a computer system, which can include both hardware and software (programs).

Ballistic Missile Any missile that does not rely upon aerodynamic surfaces to produce lift and consequently follows a ballistic trajectory when thrust is terminated. Ballistic missiles typically operate outside the atmosphere for a substantial portion of their flight path and are unpowered during most of their flight.

Ballistic Missile Defense (BMD) A defense system that is designed to protect territory from attacking ballistic missiles. Usually conceived as having several independent layers.

Battle Management The set of instructions and rules and the corresponding hardware controlling the operation of a BMD system. Sensors and interceptors are allocated by the system, and the updated battle results are presented to the (human) command for analysis and possible intervention.

Birth-to-Death Tracking The ability to track a missile and its payload from launch until it is intercepted or reaches its target.

Bistatic Radar A radar system in which the receiver and transmitter are stationed at two locations; a special case of multistatic radar.

Blackout The disabling of radar by means of a nuclear explosion. The intense electromagnetic energy released generates a large background that obscures signals and renders many types of radar useless for minutes or longer.

Booster The rocket that "boosts" the payload to accelerate it from the earth's surface into a ballistic trajectory, during which no additional force is applied to the payload.

Boost Phase The portion of a missile flight during which the payload is accelerated by the large rocket motors. For a multiple-stage rocket, the boost phase involves all motor stages. For ICBMs, this phase typically lasts from 3 to 5 minutes, but studies indicate that reductions to the order of 1 minute could be possible.

Brightness In the SDI context, the amount of power that can be delivered per unit solid angle by a directed-energy weapon.

Bus Deployment Phase The portion of a missile flight during which multiple warheads are deployed on different paths to different targets (also referred to as the post-boost phase). The warheads on a single missile are carried on a platform, or "bus" (also referred to as a post-boost vehicle), which has small rocket motors to move the bus slightly from its original path.

Capital Satellite A highly valued or costly satellite, as distinct from an inexpensive decoy satellite. Some decoys might be so expensive as to be considered capital satellites.

Chaff Confetti-like metal foil ribbons which can be ejected from spacecraft (or terrestrial vehicles) to reflect enemy radar signals, thereby creating false targets or screening actual targets from the "view" of radar.

Chemical Laser A laser in which chemical action is used to produce the pulses of coherent light.

Coherence The matching, in space (transverse) or time (temporal coherence), of the wave structure of different parallel rays of a single frequency of electromagnetic radiation. This results in the mutual reinforcing of the energy of these different components of a larger beam. Lasers can produce coherent radiation.

Coherent Light The state in which light waves are in phase over the time scale of interest. Light travels in discrete bundles of energy called photons. Each photon may be treated like an ocean wave. If all the waves are in phase, they are said to be coherent. When light is coherent, the effects of each photon build on top of the others. A laser produces coherent light and therefore can concentrate energy.

Cold Bodies Objects at or near low ambient temperature, which radiate infrared radiation. All objects radiate electromagnetic energy, and if the object is hot enough, this energy is visible light.

Command Guidance The steering and control of a missile by transmitting commands to it.

Common Mode Failure Refers to a type of system failure in which diverse components are disabled by the same single cause.

Constellation Size The number of defensive weapon satellites placed in orbit about the Earth as part of a BMD system.

Continuous-Wave Laser A laser in which the coherent light is generated continuously rather than at fixed time intervals.

Counter-Countermeasures Measures taken by the defense to defeat offensive countermeasures.

Counterforce The employment of strategic nuclear forces in an effort to destroy, or disable, selected military capabilities of an enemy force.

Countermeasures In the SDI context, measures taken by the offense to overcome aspects of a BMD system.

Cruise Missile A missile traveling within the atmosphere at aircraft speeds and, usually, low altitude, whose trajectory is preprogrammed. It is capable of achieving high accuracy in striking a distant target. It is maneuverable during flight, is constantly propelled, and therefore does not follow a ballistic trajectory. Cruise missiles may be nuclear armed.

Dazzling In the SDI context, the temporary blinding of a sensor by overloading it with an intense signal of electromagnetic radiation, e.g., from a laser or a nuclear explosion.

Decoy A device that is constructed to look and behave like a nuclear-weapon-carrying warhead, but which is far less costly, much less massive, and can be deployed in large numbers to complicate defenses.

Deep Space The region of outer space at altitudes greater than 3,000 nautical miles (about 5,600 kilometers) above the Earth's surface.

Defensive Satellite Weapon (DSAT) A device that is intended to defend satellites in space by destroying attacking ASAT weapons.

Delta-V A numerical index of the maneuverability of a satellite or rocket. It is the maximum change in velocity which a spacecraft could achieve in the absence of a gravitational field.

Diffraction The spreading out of electromagnetic radiation as it leaves an aperture, such as a mirror. The degree of spread, which cannot be eliminated by focusing, is proportional to the ratio of the wavelength of radiation to the diameter of the aperture.

Digital Processing The most familiar type of computing, in which problems are solved through the mathematical manipulation of streams of numbers.

Directed Energy Energy in the form of particle or laser beams that can be sent long distances at nearly the speed of light.

Directed-Energy Weapon A weapon that kills its target by delivering energy to it at or near the speed of light. Includes lasers and particle beam weapons.

Discriminate The process of observing a set of attacking objects and determining which are the real warheads and which are decoys and other non-threatening objects.

Dynamic Reconfiguration A means whereby a battle-management system can change its condition during a battle to respond to changing circumstances, such as the destruction of some defensive components.

Early Warning In the SDI context, the early detection of an enemy ballistic missile launch, usually by means of surveillance satellites and long-range radar.

Electromagnetic Gun A gun based on the idea of an open solenoid. The projectile is accelerated by electromagnetic forces rather that by an explosion, as in a conventional gun.

Electromagnetic Radiation A form of propagated energy, arising from electric charges in motion, that produces a simultaneous wavelike variation of electric and magnetic fields in space. The highest frequencies (or shortest wavelengths) of such radiation are possessed by gamma rays, which originate from processes within atomic nuclei. As one goes to lower frequencies, the electromagnetic spectrum includes X-rays, ultraviolet light, visible light, infrared light, microwaves, and radio waves.

Electron-Volt The energy gained by an electron in passing through a potential difference of one volt. 6.25 quintillion electron-volts equals 1 joule; 22.5 billion trillion electron-volts equals 1 kilowatt hour.

Endoatmospheric Taking place within the earth's atmosphere, generally considered as occurring at altitudes below 100 kilometers.

Ephemeris A collection of data about the predicted positions (or apparent positions) of celestial objects, including artifical satellites, at various times in the future. A satellite ephemeris might contain the orbital elements of satellites and predicted changes in these.

Excimer A contraction for "excited dimer;" a type of lasant. A dimer is a molecule consisting of two atoms. Some dimers (e.g., xenon chloride and krypton fluoride) are molecules which cannot exist under ordinary conditions of approximate thermal equilibrium but must be created in an "excited" (i.e., energized) condition by special "pumping" processes in a laser.

Exoatmospheric Taking place outside the earth's atmosphere, generally considered as occurring at altitudes above 100 kilometers.

Fast-Burn Booster A ballistic missile that can burn out much more quickly than current versions, possibly before exiting the atmosphere entirely. Such rapid burnout complicates a boost-phase defense.

Fission The breaking apart of the nucleus of an atom, usually by means of a neutron. For very heavy elements, such as uranium, a significant amount of energy is produced by this process. When controlled, this process yields energy which may be extracted for civilian uses, such as commercial electric generation. When uncontrolled, energy is liberated very rapidly: such fission is the energy source of uranium- and plutonium-based nuclear weapons; it also provides the trigger for fusion weapons.

Flexible Response A strategy to deter and, should deterrence fail, to counter aggression at varying levels with appropriate forces.

Fragment Clouds Clusters of small objects placed in front of a target in space. This is a simple way to destroy the target.

Fratricide The destructive effect of the earlier-detonating weapons in a barrage on those weapons which arrive later.

Free-Electron Laser A laser in which electrons are converted to coherent light. The electrons are supplied by an accelerator and power for the laser by electrical energy.

Functional Kill The destruction of a target by disabling vital components in a way not immediately detectable, but nevertheless able to prevent the target from functioning properly. An example is the destruction of electronics in a guidance system by a neutral particle beam.

Fusion More specifically, nuclear fusion. The fusing of two atomic nuclei, usually of light elements, such as hydrogen. For light elements, energy is liberated by this process. Hydrogen bombs produce most of their energy by the fusion of hydrogen into helium.

Gamma-Ray Laser A laser which generates a beam of gamma rays; also called a graser. A gamma-ray laser, if developed, would be a type of X-ray laser; although it would employ nuclear reactions, it need not (but might) employ nuclear fission or fusion reactions or explosions.

Gamma Rays X-rays emitted by the nuclei of atoms.

Geostationary Orbit An orbit at an altitude of 35,800 kilometers above the Earth's Equator. A satellite placed in such an orbit revolves around the Earth once per day, maintaining the same position relative to the surface of the Earth. It then appears to be stationary and can be used as a communications relay or as a surveillance post.

Geosynchronous Orbit Same as geostationary orbit.

Graser See Gamma-ray laser.

Gray The Systeme Internationale unit of absorbed dose of ionizing radiation. One gray (abbreviated 1 Gy) is 1 joule of absorbed energy per kilogram of matter.

Hardened Site A site constructed to withstand the blast and associated effects of a nuclear attack.

Hard Kill Destruction of a target in such a way as to produce unambiguous visible evidence of its neutralization.

Hardness In the SDI context, the property of a target, measured by the power needed per unit area to destroy the target by means of a directed-energy weapon. A hard target is more difficult to kill than a soft target.

Homing Device A device, mounted on a missile, that uses sensors to detect the position or to help predict the future position of a target, and then directs the missile to intercept the target. It usually updates frequently during the flight of the missile.

Hypervelocity Gun A gun that can accelerate projectiles to 5 kilometers per second or more, for example, an electromagnetic, or rail, gun.

Imaging The process of identifying an object by obtaining a high-quality image of it.

Impulse A mechanical jolt delivered to an object. Physically, impulse is a force applied for a period of time, and the Systeme Internationale unit of impulse is the newton-second (abbreviated N-s).

Impulse Intensity Mechanical impulse per unit area. The Systeme Internationale unit of impulse intensity is the pascal-second (abbreviated Pa-s). A conventionally used unit of impulse intensity is the "tap" which is one dyne-second per square centimeter; hence 1 tap = 0.1 Pa-s.

Impulse Kill The destruction of a target, using directed energy, by ablative shock. The intensity of directed energy may be so great that the surface of the target violently and rapidly boils off delivering a mechanical shock wave to the rest of the target and causing structural failure.

Inclination The inclination of an orbit is the (dihedral) angle between the plane containing the orbit and the plane containing the Earth's Equator. An equatorial orbit has an inclination of zero degrees for a satellite traveling eastward or 180 degrees for a satellite traveling westward. An orbit having an inclination between zero degrees and 90 degrees and in which a satellite is traveling generally eastward is called a prograde orbit. An orbit having an inclination of 90 degrees passes above the north and south poles and is called a polar orbit. An orbit having an inclination of more than 90 degrees is called a retrograde orbit.

Infrared Sensor A sensor to detect the infrared radiation from a cold body such as a missile reentry vehicle.

Intercept The act of destroying a target.

Inverse Synthetic Aperture Radar (ISAR) A type of radar similar to synthetic aperture radar, but which uses information from the motion of targets in order to provide high resolution.

Ionization The removal or addition of one or more electrons to a neutral atom, forming a charged ion.

Isotropic Independent of direction; referring to the radiation of energy, it means "with equal intensity in all directions," i.e., omnidirectional.

Isotropic Nuclear Weapon (INW) A nuclear explosive which radiates X-rays and other forms of radiation with approximately equal intensity in all directions. The term "isotropic" weapon is used to distinguish it from a nuclear directed-energy weapon.

Joule A Systeme Internationale unit of energy. One kilowatt-hour is 3.6 million joules.

Kill Assessment The detection and assimilation of information indicating the destruction of an object under attack. Kill assessment is one of the many functions to be performed by a battle management system.

Kinetic Energy The energy from the momentum of an object.

Kinetic-Energy Weapon A weapon that uses kinetic energy, or energy of motion, to kill an object. Weapons that use kinetic energy are a rock, a bullet, a nonexplosively armed rocket, and an electromagnetic railgun.

Ladar A technique analogous to radar, but which uses laser light rather than radio or microwaves. The light is bounced off a target and then detected, with the return beam providing information on the distance and velocity of the target.

Laddering Down A hypothetical technique for overcoming a terminal phase missile defense. Successive salvos of salvage-fused reentry vehicles attack. The detonations of one salvo disable local ABM abilities so that following salvos are able to approach the target more closely before being, in turn, intercepted. Eventually, by repeating the process, the target is reached and destroyed.

Lasant A material that can be stimulated to produce laser light. Many materials can be used as lasants; these can be in solid, liquid, or gaseous form (consisting of molecules — including excimers — or atoms) or in the form of a plasma (consisting of ions and electrons). Lasant materials useful in high energy lasers include carbon dioxide, carbon monoxide, deuterium fluoride, hydrogen fluoride, iodine, xenon chloride, krypton fluoride, and selenium, to mention but a few.

Laser A device for generating coherent visible or infrared light.

Laser Designator The use of a low-power laser to illuminate a target so that a weapon equipped with a special tracker can home in on the designated target.

Laser Imaging A new technology where a laser beam can be used in a way similar to a radar beam to produce a high-quality image of an object.

Laser Tracker The process of using a laser to illuminate a target so that specialized sensors can detect the reflected laser light and track the target.

Layered Defenses The use of several layers of BMD at different phases of the missile trajectory. Each layer is designed to be as independent as possible of the others, and each would probably use its own, distinctive set of missile defense technologies.

Leakage The percentage of warheads that get through a defensive system intact and operational.

Leverage In the SDI context, refers to the advantage gained by boost-phase intercept, when a single booster kill may eliminate many reentry vehicles and decoys before they are deployed. This could provide a favorable cost exchange ratio for the defense, and would reduce stress on later layers of the defense system.

LIDAR Same as ladar.

Megawatt One million watts; a unit of power. A typical commercial electric plant generates about 500 to 1,000 megawatts.

MeV One million electron-volts. A unit of energy usually used in reference to nuclear processes. It is equivalent to the energy that an electron gains in crossing a potential of 1 million volts.

Micron One-millionth of a meter (equivalently, one-thousandth of a millimeter). Roughly twice the wavelength of visible light.

Midcourse Phase The long period of a warhead's flight to its target after it has been dispensed from the post-boost vehicle until it reenters the atmosphere over its target. This phase lasts up to 20 minutes.

Military Satellite (MILSAT) A satellite used for military purposes, such as navigation or intelligence gathering.

Miniature Homing Vehicle (MHV)/Miniature Vehicle (MV) An air-launched direct-ascent ("pop-up") kinetic-energy ASAT weapon currently being developed and tested by the U.S. Air Force.

Monostatic Radar A radar system in which the receiver and transmitter are co-located.

Multiple Independently-Targetable Reentry Vehicle (MIRV) One of several reentry vehicles on the same post-boost phase vehicle that can be independently placed on a ballistic course towards a target after completion of the boost phase.

Multiple Phenomenology A system using repeated observations of potential targets by means of different physical principles and different sensor systems. In the case of sensor systems, the use of multiple phenomenology makes it more difficult for an adversary to deceive them.

Multiple Reentry Vehicle (MRV) The reentry vehicle of a ballistic missile which is equipped with multiple warheads but which does not have the capability of independently directing the reentry vehicles to separate targets.

Multispectral Sensing A method of using many different bands of the spectrum to sense a target, for example, visible and infrared light. If several bands are used, deceptive measures become much more difficult.

Multistatic Radar A radar system with a transmitter and several receivers, all separated.

Neutral-Particle Beam An energetic beam of neutral atoms (no net electric charge). A particle accelerator moves the particle to nearly the speed of light.

Obscurant A material (e.g., smoke or chaff) used to conceal an object from observation by a radio or optical sensor. Smoke may be used to conceal an object from observation by an optical sensor, and chaff may be used to conceal an object from observation by a radio sensor (e.g., radar).

On-line Operating, as distinct from dormant.

Optical Processing A type of analog processing passed through optical systems in which the behavior of light beams, passed through optical systems, is used in problem solving.

Parallel Processing The use of different paths in a computer to work simultaneously on different calculations needed to solve a single problem, thus reducing the time needed for the overall calculation.

Particle Beam A stream of atoms or subatomic particles (electrons, protons, or neutrons) accelerated to nearly the speed of light.

Passive Sensor A sensor that only detects radiation naturally emitted (infrared radiation) or reflected (sunlight) from a target.

Payload The weapons and penetration aids carried by a delivery vehicle.

Penetration Aids Methods to defeat defenses by camouflage, deception, decoys, and countermeasures.

Phased-Array Radar (PAR) A radar with elements that are physically stationary, but with a beam that is electronically steerable and can switch rapidly from one target to another. Used for tracking many objects, often at great distances.

Pointing The aiming of sensors or defense weapons at a target with sufficient accuracy either to track the target or to aim with sufficient accuracy to destroy it.

Post-Boost Phase The phase of a missile trajectory, after the booster's stages have finished firing, in which the various reentry vehicles are independently placed on ballistic trajectories towards their targets. In addition, penetration aids are dispensed from the post-boost vehicle. The length of this phase is typicallly 3 to 5 minutes, but could be drastically reduced.

Post-Boost Vehicle The portion of a rocket payload that carries the multiple warheads and has maneuvering capability to place each warhead on its final trajectory to a target (also referred to as a "bus").

Power Supply In the SDI context, a source of energy for a BMD component. It may be ground- or space-based, and may range from commercial electric plants to space-based nuclear reactors.

Preferential Defense The concentration of (usually limited) defensive assets on a subset of sites in order to assure the survival of some of them.

Preferential Offense The concentration of offensive assets on a subset of targets.

Pumping In the SDI context, the raising of the molecules or atoms of a lasant to an energy state above the normal lowest state, in order to produce laser light. This results when they fall back to a lower state. Pumping may be done using electrical, chemical, or nuclear energy.

Rad A unit of absorbed dose of ionizing radiation. One rad is 0.001 gray.

Radar A technique for detecting targets in the atomsphere or in space by transmitting radio waves (e.g., microwaves) and sensing the waves reflected by objects. The reflected waves (called "returns" or "echos") provide information on the distance to the target and the velocity of the target and may also provide information about the shape of the target. (Originally an acronym for "Radio Detection And Ranging.")

Radian A unit of angular measure. One radian is about 57.3 degrees. One microradian (0.000001 radian) is the angle subtended by an object 1 meter across at a distance of 1,000 kilometers.

Radiant Energy The energy from radiation such as electrons, protons, or alpha particles.

Reaction Decoy A decoy deployed only upon warning or suspicion of imminent attack.

Real-Time Protocols Computer programs capable of making decisions as rapidly as input information is received.

Redout The blinding or dazzling of infrared detectors due to high levels of infrared radiation produced in the upper atmosphere by a nuclear explosion.

Reentry The return of objects, orginally launched from Earth, into the atmosphere.

Reentry Vehicle (RV) In the SDI context, reentry vehicles are small containers containing nuclear warheads. They are released from the last state of a booster rocket or from a post-boost vehicle early in the ballistic trajectory. They are thermally insulated to survive rapid heating during the high velocities of reentry into the atmosphere, and are designed to protect their contents until detonation at their targets.

Repetitively Pulsed Laser A laser that fires its beam in sequential short bursts, as opposed to a continuous beam or a single pulse.

Responsive Threat Offensive forces that have been modified to defeat a defensive system.

Robust In the SDI context, indicating the ability of a system to endure and perform its mission against a reactive adversary. Also used to indicate ability to survive under direct attack.

Safeguard A U.S. midcourse and terminal-phase defense for ICBMs, deployed in 1975 and deactivated in 1976 due to its limited cost-effectiveness.

Salvage-fused Describing a warhead that is set to detonate when it is attacked. Usually refers to a nuclear warhead.

Selectivity In the SDI context, refers to choosing a subset of targets, either for attack or defense. See preferential defense and preferential offense.

Semi-Active Sensor One that does not generate radiation itself, but that detects radiation reflected by targets when they are illuminated by other BMD components. Such devices are used for tracking and identification and can operate without revealing their own locations.

Sensors Electronic instruments that can detect radiation from objects at great distances. The information can be used for tracking, aiming, discrimination, attacking, kill assessment or all of the above. Sensors may detect any type of electromagnetic radiation or several types of nuclear particles.

Sentinel ABM system designed for light area defense against a low-level ballistic missile attack on the United States. Developed into the Safeguard system in late 1960s

Shoot-back In the SDI context, the technique of defending a space asset by shooting at an attacker.

Signal Processing A computer system's capability to organize the raw data received from many different sources.

Signature Distinctive type of radiation emitted or reflected by a target, which can be used to identify that target.

Simulation The art of making a decoy look like a more valuable strategic target (cf. anti-simulation).

Single-Event Upset Electronic components of a battle-management system performing abnormally because of radiation.

Slew Time The time needed for a weapon to reaim at a new target after having just fired at a previous one.

Smoke An obscurant which may be used in the atmosphere or in space to conceal an object from observation by an optical sensor.

Soft Kill Same as functional kill.

Space Mines Hypothetical devices that can track and follow a target in orbit, with the capability of exploding on command or by pre-program, in order to destroy the target.

Spartan Nuclear-armed long-range midcourse interceptor used in Safeguard/Sentinel systems.

Sprint Nuclear-armed short-range interceptor used in Safeguard/Sentinel systems.

SS-18 Largest ICBM in current Soviet inventory, credited with carrying 10 reentry vehicles, but capable of holding many more.

Stimulated Emission Physical process by which an excited molecule is induced by incident radiation to emit radiation at an identical frequency and in phase with the incident radiation. Lasers operate by stimulated emission.

Structured Attack Timing the arrival of a sequence of warheads at their targets to create maximum destructive effects.

Superradiance The process used by a superradiant laser to generate or amplify a laser beam in a single pass through a lasant material, or — in the case of a free-electron laser — through an electric or magnetic field in the presence of an electron beam. Superradiance is actually a form of stimulated emission. Also known as superfluorescence, or amplified spontaneous emission.

Superradiant Laser A laser in which the beam passes through the lasant only once; mirrors are not required for the operation of such a laser, as they are with more conventional lasers which are sometimes called "cavity lasers" to distinguish them from superradiant lasers. Free-electron lasers may also be superradiant; the laser beam of a superradiant free-electron laser would pass once through an electric or magnetic field (instead of a lasant) in the presence of an electron beam.

Synthetic Aperture Radar (SAR) A radar technique that processes echoes of signals emitted at different points along a satellite's orbit or an airplane's flight path. The highest resolution achievable by such a system is theoretically equivalent to that of a single large antenna as wide as the distance between the most widely spaced points along the orbit that are used for transmitting positions. In practice, resolution will be limited by the radar receiver's signal-processing capability or by the limited coherence of the radio signal emitted by the radio transmitter.

Terminal Phase The final phase of a ballistic missile trajectory, during which warheads and penetration aids reenter the atomsphere.

Thermal Kill The destruction of a target by heating it, using directed energy, to the degree that structural components fail.

Threat The anticipated inventory of enemy weapons. In the SDI context, the inventory is of nuclear weapons and their delivery systems, as well as of decoys, penetration aids, and other BMD countermeasures.

Threat Clouds Dense concentrations of both threatening and nonthreatening objects. The defense must distinguish between them.

Throw-Weight The useful weight placed on a trajectory toward the target by the boost or main propulsion stages of the missile.

Track File Information stored in computer memory containing position coordinates and velocity components of a target. In the SDI context, refers to such information concerning offensive weapons during their trajectories: e.g., boosters, rentry vehicles, decoys.

Tracking The monitoring of the course of a moving target. Ballistic objects may have their tracks predicted by the defensive system, using several observations and physical laws.

Transition In the SDI context, the period in which the world strategic balance would shift from offense-dominance to defense-dominance.

Warhead The part of a missile, projectile, torpedo, rocket, or other munition containing either the nuclear or the thermonuclear system, high explosive system, chemical or biological agents, or inert materials intended to inflict damage.

X-ray Laser A laser which generates a beam or beams of X-rays. Also called an "x-raser" or "XRL."

X-rays Electromagnetic radiation having wavelengths shorter than 10 nanometers (10 billionths of a meter).

SELECTED BIBLIOGRAPHY

The Status of the U.S. Program

1. Broad, William. "Reagan's Star Wars Bid: Many Ideas Converging." *New York Times*, March 4, 1985.

   The role of Dr. Edward Teller, and third-generation weapons, in President Reagan's "Star Wars" proposal. The Bethe-Teller dispute as it parallels the proponents of political viz technological solutions to the world's ills. How Reagan's "kitchen cabinet" split over the tough questions concerning SDI. Questions whether the goal is defense or nuclear superiority.

2. Carter, Ashton B. "Directed Energy Missile Defense in Space." Background Paper. Prepared for the Office of Technology Assessment, Congress of the United States, April 1984.

   A description and assessment of current concepts in directed-energy ballistic missile defense, prepared for members of Congress and the general public. Also discusses the arms control implications of such a system.

3. Fletcher, James C. "The Technologies for Ballistic Missile Defense." *Issues in Science and Technology*, Fall 1984, 15-29.

   Chairman of the Fletcher Commission posits his views on the technology of ballistic missile defense (BMD) with recommendations for a vigorous R&D program. Defines "missing" technologies. Describes technological challenges as "great but not insurmountable." Sees SDI as an opportunity for strengthening deterrence.

4. Gerry, Edward T. "The Strategic Defense Initiative." Paper presented at the Conference on Nuclear Deterrence — New Risk, New Opportunities, University of Maryland, College Park, Maryland, September 5, 1984.

   Provides explanation for SDI as primary basis for deterrence by removing the first strike capability of the other side. Explores technological advances in "layered" defense.

5. Gerry, Edward T. "The Strategic Defense Initiative." Paper presented to the American Physical Society, Boston, Massachusetts, November 1, 1984.

   Answers the question: "Why change U.S. nuclear strategy from MAD?" with a variety of answers, relating to SDI and ultimate stability. Also addresses the technology issues.

Prepared by Nancy Long Arneson, Consultant to the Center for the Study of Foreign Affairs

6. Golden, Frederic. "Special Report: Star Wars." *Discover*, September 1985, 28-42.

A status report on research on the SDI.

7. Lardner, George, Jr. "General Graham's Star Wars." *Washington Post Magazine*, November 17, 1985.

Articles describe High Frontier's Danny Graham, the High Frontier organization itself, and their interest in the President's SDI program.

8. McFarlane, Robert C. Speech before the Overseas Writers Association, March 7, 1985. Current Policy no. 670.

Department of State, Bureau of Public Affairs. The President's National Security Advisor examines post-SALT strategic weapons history in the United States and the Soviet Union as well as the basic premises of deterrence. Outlines three options open to the United States, and dispels four SDI "myths."

9. Sagan, Carl. "The Case Against SDI." *Discover*, September 1985, 66-75.

Countering Edward Teller, this famed author and astronomer argues against SDI in terms of lack of feasibility and humanitarian concerns.

10. Sloss, Leon. "The Return of Strategic Defense." *Strategic Review*, Summer 1984.

Author contends that U.S. emphasis on offensive weapons has resulted in strategic assymetry and, ultimately a weakening of deterrence. Feels that SDI leads to a more balanced mix which is, in the final analysis, beneficial.

11. U.S. Congress, Office of Technology Assessment. *Ballistic Missile Defense Technologies*. September 1985.

A study, performed at the request of House Armed Services Committee and Senate Foreign Relations Committee, on the relative risks and opportunities involved in BMD technologies. Examines both the reasons for and the capabilities for ballistic missile defense.

12. U.S. Department of Defense. *Report to the Congress on the Strategic Defense Initiative*. 1985.

This report, written in response to Congressional requirements, encompasses plans for present and future efforts by the Defense Department to achieve the various goals of the SDI.

13. U.S. Department of Defense. *Report to the Congress: U.S. Policy in ASAT Arms Control*. March 31, 1984.

Discusses space arms control goals and how ASAT furthers national security objectives. Outlines problems which face ASAT arms control as well as problems of definition.

14. U.S. Department of Defense. *SDI: A Technical Progress Report. Submitted to the Secretary of Defense by the Director of the Strategic Defense Initiative Organization.* June 1985.

Contains reports by Defensive Technologies Team and Future Security Team, with an introduction by Secretary of Defense Weinberger. Poses questions which will affect deployment decisions. Defines key functions of BMD.

15. U.S. Department of Defense. *The Strategic Defense Initiative Defensive Technologies Study.* April 1984.

Report of the Fletcher Commission outlines three major aspects of SDI: innovation, forward technology programs, and technical demonstrations. Posits the Commission's overall conclusions and provides glossary of technical terms.

16. Yonas, Gerold. "Weapons in Space: Volume I: Concepts and Technologies." *Daedalus*, Spring 1985.

Describes background to technological exploration of SDI. Reports early efforts of the Defense Technologies Study Team (DTST). Outlines the various components of BMD system.

The Soviet Program

1. Mohr, Charles. "What Moscow Might Do in Replying to 'Star Wars'." *New York Times*, March 6, 1985, p. 1.

Starts with the contention that Soviets and U.S. are equals in space- and land-based BMD. The Soviet program from the perspective of Sovietologists in the U.S. Some analysts fear Soviets closer to nation-wide BMD than the U.S.

2. Nitze, Paul H. "SDI: The Soviet Program." Speech to the Chautauqua Conference on Soviet-American Relations, Chautauqua, New York, June 28, 1985. Current Policy no. 717. Department of State, Bureau of Public Affairs.

An analysis of the Soviet version of SDI and other ABM-related activities by the Special Advisor to the President and the Secretary of State on Arms Control Matters. A technological discussion of lasers, particle beams, radio frequency, kinetic energy and other weapons being produced by the Soviet Union.

3. U.S. Department of Defense. *Soviet Military Power.* Washington, DC: U.S. Government Printing Office, 1985.

Describes Soviet concept of "layered defense" and its individual components. A highly definitive status report for the Soviet program, providing details of treaty violations. Also describes Soviet "passive defense" system.

4. U.S. Department of State, Bureau of Public Affairs. "Security and Arms Control: The Search for a More Stable Peace." September 1984.

A brief summary of U.S. and Soviet status in the area of missile defense and how it accords with arms control treaties.

Arms Control and the SDI

1. Adelman, Kenneth L. "SDI: Setting the Record Straight." Speech to the Baltimore Council on Foreign Affairs, August 7, 1985. Current Policy no. 730. Department of State, Bureau of Public Affairs.

The Director of the U.S. Arms Control and Disarmament Agency lists "impossible" situations akin to SDI as a take-off for discussion of questions regarding this proposal, most particularly the congruence of SDI with the ABM Treaty, the Non-Proliferation Treaty, and arms control generally.

2. "Aerospace Experts Challenge ASAT Decision." *Science*, May 19, 1984, 693-696.

Describes the ASAT "war" in Congress as well as the President's position. Investigates the issue of verification and how ASAT fits in with arms control.

3. Bundy, McGeorge, Kennan, George F., McNamara, Robert S., and Smith, Gerard. "The President's Choice: Star Wars or Arms Control." *Foreign Affairs*, Winter 1984.

Raises a host of questions about SDI. It calls on Congress to "enforce" arms control treaties and asks the President to reconsider the SDI and pursue arms control instead.

4. Durch, William J., editor. *National Interests and the Military Use of Space*. Cambridge, MA: Ballinger Publishing Co., 1984.

Takes a close look at the strategic significance and implications for security of space weapons.

5. Gelb, Leslie H. "Weapons in Space: The Controversy Over 'Star Wars'." *New York Times*, March 3, 1985, p. 1.

Compares "myth" and "reality" of the proposed SDI. Calls it "the touchstone of loyalty to the President." Asks whether SDI will set off a major arms race. Touches on various officials, in and out of government, and their arguments for or against the system. Asks whether it encourages a first strike by the Soviets.

6. Gray, Colin S. "The Military Uses of Space." *Survival*, September–October 1983, 194-204.

Asks questions regarding the strategic mission for weapons in space. Describes uses such as surveillance and reconnaissance, attack warning and assessment, communication and navigation. A technical discussion of the issues, and analysis of ASAT arms control. Author dismisses the notion of space as a "sanctuary."

7. Guertner, Gary L. "What is 'Proof'?" *Foreign Policy*, Summer 1985, 73-84.

Author analyzes the feasibility of SDI and its cost-effectiveness, as well as the difficulty of assessment and its interrelationship with arms control. Posits problem of legal analysis regarding violations of the ABM treaty.

8. Keyworth, George A. "The Case For." *Issues in Science and Technology*, Fall 1984, 30-44.

Poses dichotomy between "Ban the Bomb" and "Don't Rock the Boat" factions and options to resolve the dilemma. Sees the SDI as a catalyst for arms control, while admitting that all security is essentially political.

9. Meyer, Stephen M. "Soviet Military Programmes and the 'New High Ground'." *Survival*, September—October 1983, 204-215.

Contends that the Soviets exceed U.S. in its space program and are accelerating their programs. Asks key questions regarding their militarization of space. Assesses impact of the Soviet space program on their global military involvement. Provides a review of early Soviet space weaponry. Posits overall conclusion on Soviet space program.

10. Nitze, Paul H. "SDI and the ABM Treaty." Commencement address before the Johns Hopkins School of Advanced International Studies, May 30, 1985. Department of State, Bureau of Public Affairs.

An explanation of SDI and its interaction with the ABM treaty and arms control generally, as well as an assessment of U.S. reappraisal towards strategic defense, by the Special Advisor to the President and the Secretary of State on Arms Control Matters.

11. Rivkin, David B., Jr. "What Does Moscow Think?" *Foreign Policy*, Summer 1985, 85-105.

Analyzes SDI from the Soviet perspective and sees a defense-oriented world as beneficial to the Soviet Union. Examines basic, historical Soviet strategic doctrine.

12. Shultz, George. "Arms Control: Objectives and Prospects." Speech to the Austin Council on Foreign Relations, Austin, Texas, March 28, 1985. Current Policy no. 675. Department of State, Bureau of Public Affairs.

An address by the Secretary of State on U.S. foreign policy, Soviet arms control violations, and U.S. objectives in Geneva in terms of long-term arms control goals. Also tackles SDI and the cost-effectiveness issue as well as the Soviet counterpart.

13. U.S. Congress, Office of Technology Assessment. *Arms Control in Space: Workshop Proceedings*. 1984.

Workshop focuses on anti-satellite (ASAT) weapons, exploring technical, diplomatic, military and policy aspects. It outlines points of general agreement among the experts, as well as areas of disagreement and topics for continuing research.

14. U.S. Department of State, Bureau of Public Affairs. "Building an Interim Framework for Mutual Restraint." Special Report no. 131. June 10, 1985.

President Reagan's statement, message to Congress, and unclassified Fact Sheet of June 10, 1985. The President calls for restraints on production of strategic offensive arms. Details history of Soviet compliance with SALT I and II.

15. The White House. "The President's Strategic Defense Initiative." January 1985.

The President questions the basic assumptions of deterrence, in reproposing the SDI and speaks of the concomitant need for arms control. Speech contains explanation of the original SDI proposal by the President in March 23, 1983, speech. Presents concept of local defense to enhance deterrence, while dovetailing with arms control.

The Strategic Implications of SDI

1. Boffey, Philip M. "Dark Side of 'Star Wars': System Could Also Attack." *New York Times*, March 7, 1985, p. 1.

Critics allege that SDI could also have offensive capability, which would enable defensive capability to be held in reserve against retaliatory strike. Asks the question: What are the targets of SDI? Proponents claim SDI weapons are "precise weapons that destroy only precise targets."

2. Boffey, Philip M. "'Star Wars' and Mankind: Unforeseeable Directions." *New York Times*, March 8, 1985, p. 1.

Captures some of the dialogue on Capitol Hill regarding the "Star Wars" program. Explores the status of research. Opponents see existence of nuclear weapons as guarantors of peace. Examines various "layers" of debate, both pro and con. Poses the problems of the transitional phase.

3. Carter, Ashton B., and Schwartz, David N., editors. *Ballistic Missile Defense*. Brookings Institution and the Massachusetts Institute of Technology, 1984.

Examines the strategic, political and technological issues raised by ballistic missile defense (BMD) in light of President Reagan's March 23, 1983, speech in which he introduced the SDI.

4. Drell, Sidney D., and Panofsky, Wolfgang K.H. "The Case Against: Technical and Strategic Realities." *Issues in Science and Technology*, Fall 1984.

Explains the theory of mutual assured destruction (MAD) and the fact that "enhancement of stability" is of mutual interest as a backdrop to investigation of various "selling points" of SDI. Questions ultimate congruence of SDI and existing arms control treaties.

5. Hecht, Jeff. *Beam Weapons: The Next Arms Race.* New York and London: Plenum Press, 1984.

An analysis of laser and beam weapons in terms of security and instability. An assessment of their current status.

6. Hoffman, Fred. "The SDI in U.S. Nuclear Strategy." *International Security,* Summer 1985, 13-24.

Claims that, while the U.S. has relied on MAD, the Soviets have swung the nuclear balance in their favor. Questions the Soviet belief in MAD and the "law of action and reaction." Calls for a prudent approach to SDI.

7. McNamara, Robert S., and Bethe, Hans A. "Reducing the Risk of Nuclear War." *Atlantic,* July 1985, 43-51.

Authors question whether current policymakers believe President Reagan's adage that "a nuclear war cannot be won and must never be fought." They analyze what they term Star Wars I and II, posit restructuring of nuclear forces as an alternative, and comment on Nitze's Philadelphia Speech.

8. Nitze, Paul H. "On the Road to a More Stable Peace." Speech to the Philadelphia World Affairs Council, February 20, 1985. Current Policy no. 657. Department of State, Bureau of Public Affairs.

The Special Advisor to the President and the Secretary of State on Arms Control Matters challenges basic tenets of deterrence and sets the stage for "non-nuclear defense that might make possible the eventual elimination of nuclear weapons." Discusses the cost-effectiveness issue and the problems inherent in the transitional period.

9. Nitze, Paul H. "Towards a Nuclear Free World." Speech to the Los Angeles World Affairs Council, February 28, 1985.

Questions premises of deterrence. Sees SDI as catalyst for eventual elimination of all nuclear weapons. Discusses survivability and cost-effectiveness issues. Proposes concept of "mutual assured security" in place of MAD.

10. Perle, Richard. Interview, March 1985. *Harvard International Review,* March/April 1985, 11-13.

The Assistant Secretary of Defense for International Security Policy contends that SDI has increased Soviet interest in arms control and discounts the theory that SDI could be utilized as a "bargaining chip" in negotiations.

11. Schlesinger, James R. "Rhetoric and Realities in the Star Wars Debate." *International Security,* Summer 1985, 13-24.

Criticizes proponents of SDI and their phrase, "the immorality of deterrence." Makes the claim that no defense will ever be impenetrable. Questions the concept of "mutual assured survival." Proposes that the best role for SDI is that of the classical bargaining chip.

12. Simes, Dimitri. Interview, March 1985. *Harvard International Review*, March/April 1985, 7-10.

In context of arms control negotiations, this well-known Sovietologist from the Johns Hopkins School of Advanced International Studies discusses the Strategic Defense Initiative, its supporters and detractors and how it affects arms control negotiations.

13. Talbott, Strobe. Interview, March 1985. *Harvard International Review*, March/April 1985, 13-15.

In arms control context, this *Time* magazine correspondent analyzes SDI and European views on the subject.

14. Teller, Edward. "The Case for the Strategic Defense Initiative." *Discover*, September 1985, 66-75.

This renowned physicist argues the case for using defense as a deterrent in place of mutual assured destruction (MAD).

15. U.S. Congress, Office of Technology Assessment. *Anti-Satellite Weapons, Countermeasures, and Arms Control*. September 1985.

Study done at request of House Armed Services Committee and Senate Foreign Relations Committee which assesses implications of ballistic missile defense technologies and others similar to it. Report examines options open to U.S. for countering Soviet military satellite capabilities and measures to limit ASAT threat. Also examines pros and cons of various arms control ideas for space weapons.

16. U.S. Department of State, Bureau of Public Affairs. "The Strategic Defense Initiative." Special Report no. 129. June 1985.

An explanation of SDI in the strategic context, most specifically in terms of deterrence. It presents a view of Soviet status in the strategic balance and how that status effects deterrence. Answers twelve questions relating to SDI.

Allied Views

1. Alterman, Eric R. "European Leaders' Quandry." *New York Times*, July 11, 1985, p.23.

Expresses European fears of SDI in terms of their vulnerability, in the event of attack, and in the world commercial marketplace.

2. Drodziak, William. "Bonn Delegation Comes to U.S. to Discuss 'Star Wars' Participation." *Washington Post*. September 5, 1985.

Highlights U.S. tour by German delegation, investigating the technological opportunities of SDI. Assesses impact of French "Eureka" concept.

3. Galler, Paul E., Lowenthal, Mark M., and Smith, Marcia S. "The Strategic Defense Initiative and United States Alliance Strategy." Report no. 85-48F. Congressional Research Service, Library of Congress, February 1985.

Addresses concerns of the European allies and the Japanese, on a case by case basis, with regard to the SDI and the increased likelihood of war, if it were actually deployed. Expresses fear of "making the world safe for conventional warfare."

4. Ottaway, David B. "Agreement Near With Bonn and London on SDI Research." *Washington Post*, September 17, 1985.

   Describes breakthrough when Germany and United Kingdom announce plans to participate in SDI research. Assesses the impact on the Soviet Union as well as Congress.

5. Pierre, Andrew J. "An Irritant to Japan?" *New York Times*, July 11, 1985, p. 23.

   States how the Japanese see SDI in terms of their friendship with President Reagan and the non-nuclear principles adopted after World War II. A caveat against pressuring the Japanese in a manner parallel to trade.

* U.S. GOVERNMENT PRINTING OFFICE: 1986-160-071:50576

CENTER FOR THE STUDY OF FOREIGN AFFAIRS

The Center for the Study of Foreign Affairs, established in late 1982 as part of the Foreign Service Institute, aims to enrich traditional Foreign Service training by keeping government officials in many agencies abreast of emerging foreign policy concepts. Its program of conferences, research, diplomatic exercises and simulation, and publication combines new perspectives developed in the private sector with practical experience gained by foreign affairs personnel.

Conferences

In the last three years, the Center has organized more than 75 conferences and workshops involving approximately 5,000 participants. These bring together academicians, businessmen, senior government officials, distinguished private citizens, and Center researchers for in-depth discussions of foreign policy issues organized around a number of topics: international negotiation and conflict resolution; Soviet studies; bilateral and regional issues; science, technology and foreign affairs; economics; building democratic institutions; and development of the Foreign Service.

The results of conferences are summarized in three-page leaflets in the "Fresh Look" series. These are available upon request.

Research

The Center facilitates research by foreign affairs personnel and provides a Washington base and an opportunity for participation in State Department activities for selected professors on sabbatical leave. The research undertaken by these individuals is coordinated by the Center and brought to the attention of government decision-makers.

Exercises and Simulations

A new Center activity is to develop an exercise and simulation program for the Department of State. Each year several exercises and simulations will be developed, using the reservoir of expertise within the Department of State and related agencies. These teaching instruments will provide a dynamic dimension to the training of Foreign Service officers and, as analytic tools, will be able to help policymakers avoid diplomatic mistakes.

Publications

The Center publishes full-length studies of various foreign policy issues in its Study of Foreign Affairs series—many of these are based on conferences and workshops held at the Center. These are available for purchase through the Government Printing Office. (A list of current titles may be found on the back cover of this book.) In addition, several shorter studies are available in the Occasional Paper series. (Occasional papers published so far deal with the Iran-Iraq war, the history of the Foreign Service from 1776 to the Civil War, and "Crisis in Al Jazira," a foreign policy simulation.)

OTHER PUBLICATIONS IN THE CENTER'S STUDY OF FOREIGN AFFAIRS SERIES

How to Be A Delegate, John W. McDonald, Jr. A practical guide for newcomers to multilateral diplomacy. 1984, $2.00, GPO stock #044-000-02044-1, 54 pages, index, glossary.

International Negotiation: Art and Science, ed. John W. McDonald, Jr., and Diane B. Bendahmane. Report of a conference of experts on international negotiation. 1984, $2.75, GPO stock #044-000-02124-2, 85 pages, bibliography.

Science, Technology and Foreign Affairs, Vol. I: Global Environment, Communications, and Agriculture, ed. David W. McClintock and Diane B. Bendahmane. An exploration of issues of increasing importance in our foreign policy. 1984, $3.50, GPO stock #044-000-02049-1, 144 pages, bibliography.

Science, Technology and Foreign Affairs, Vol. II: Climate, Scientific Dialogue and Health, ed. David W. McClintock and Diane B. Bendahmane. 1985, $4.25, GPO stock #044-000-02043-2, 122 pages, bibliography.

Multinational Peacekeeping in the Middle East, Robert B. Houghton and Frank G. Trinka. A study of four multinational peacekeeping operations analyzing what factors make for success. 1984, $3.50, GPO stock #044-000-02123-4, 108 pages, bibliography.

Robotics and Foreign Affairs, ed. David T. Morrison and Diane B. Bendahmane. Based on a symposium held in 1984 at George Washington University. 1985, $2.75, GPO stock #044-000-02061-1, 94 pages, bibliography.

Perspectives on Negotiation, ed. John W. McDonald and Diane B. Bendahmane. Four case studies on international negotiations (the Panama Canal treaties, the Falkland/Malvinas Islands crisis, the Cyprus dispute, and negotiating Zimbabwe's independence) together with an analysis of lessons learned. 1986, $7.50, GPO stock #044-000-02113-7, 315 pages, bibliography.

The New Jewel Movement: Grenada's Revolution, 1979-1983, Gregory Sandford. A study of how the movement grew and why the revolution destroyed itself. 1985, $5.00, GPO stock #044-000-02059-9, 215 pages, bibliography, index.

Toward a Better Understanding: U.S. - Japan Relations, ed. Leo Moser and Diane B. Bendahmane. Based on a two day symposium discussing decision-making and economic, cultural, political and military relations. 1986, $4.25, GPO stock #044-000-02122-6, 152 pages, bibliography.

These publications are available from the U.S. Government Printing Office, Washington, D.C. Upcoming publications will deal with three economic case studies, informal diplomacy, U.S. base negotiations, black labor unions in South Africa, the future of GATT, and countries in transition from dictatorship. For information on these upcoming works, write to the Center for the Study of Foreign Affairs, 1400 Key Boulevard, Arlington, Virginia 22209.